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Chawgo et al.

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(54) **COAXIAL CABLE CONNECTOR**

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Related U.S. Application Data

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(51) **Int. Cl.**

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H01R 24/56	(2011.01)
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CPC ***H01R 24/38*** (2013.01); ***H01R 9/0524*** (2013.01); ***H01R 24/56*** (2013.01); *H01R 2103/00* (2013.01)
USPC **439/578**; 430/583; 430/584; 430/585

(58) **Field of Classification Search**
CPC H01R 9/0524; H01R 24/56; H01R 24/38
USPC 439/578, 583, 584, 585
See application file for complete search history.

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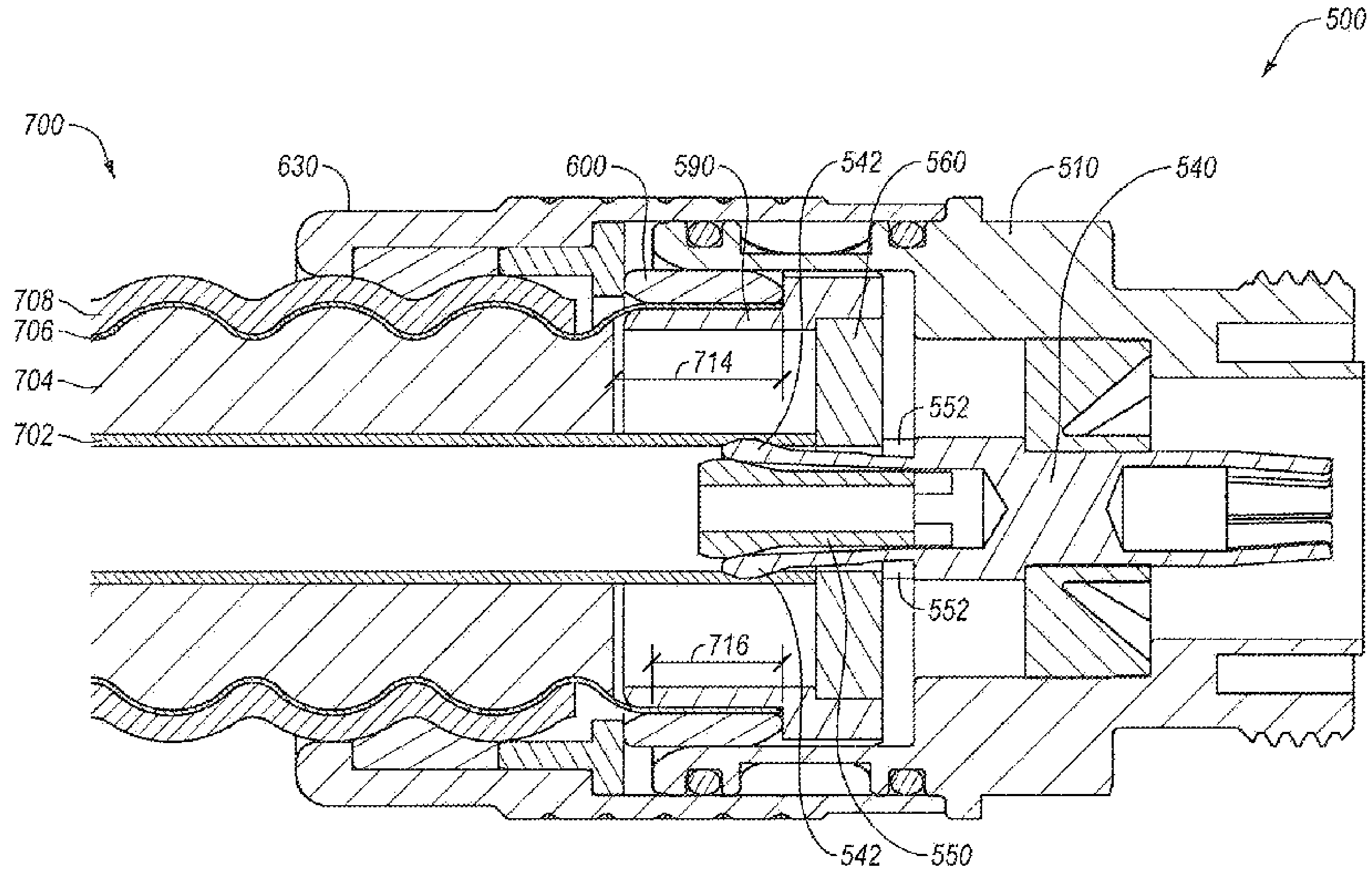
(57) **ABSTRACT**

A coaxial cable connector includes, in one embodiment, a coupler, a body, an inner conductor engager and an outer conductor engager. The connector also includes a driver configured to axially move along an axis as a result of at least one axial installation force.

64 Claims, 21 Drawing Sheets



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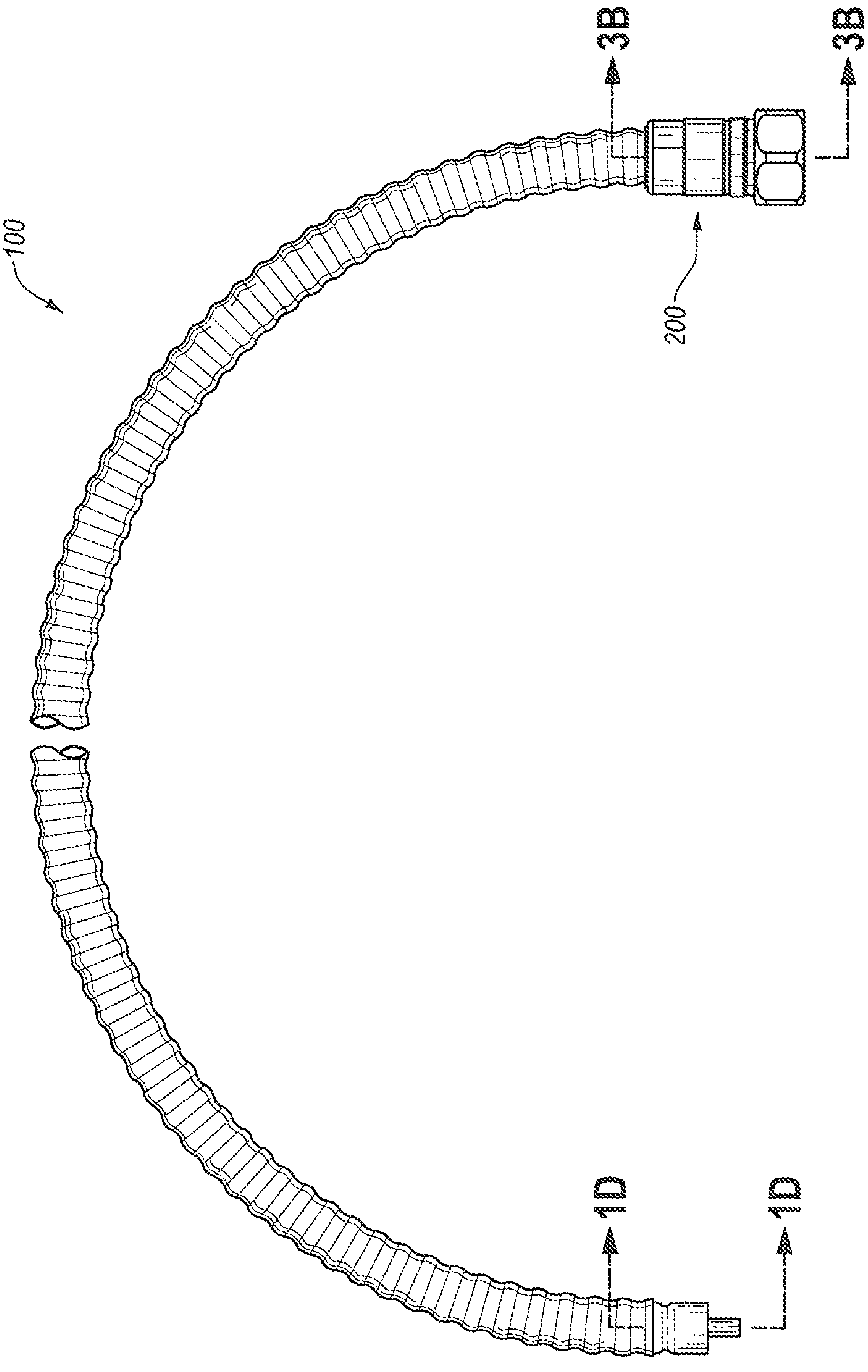
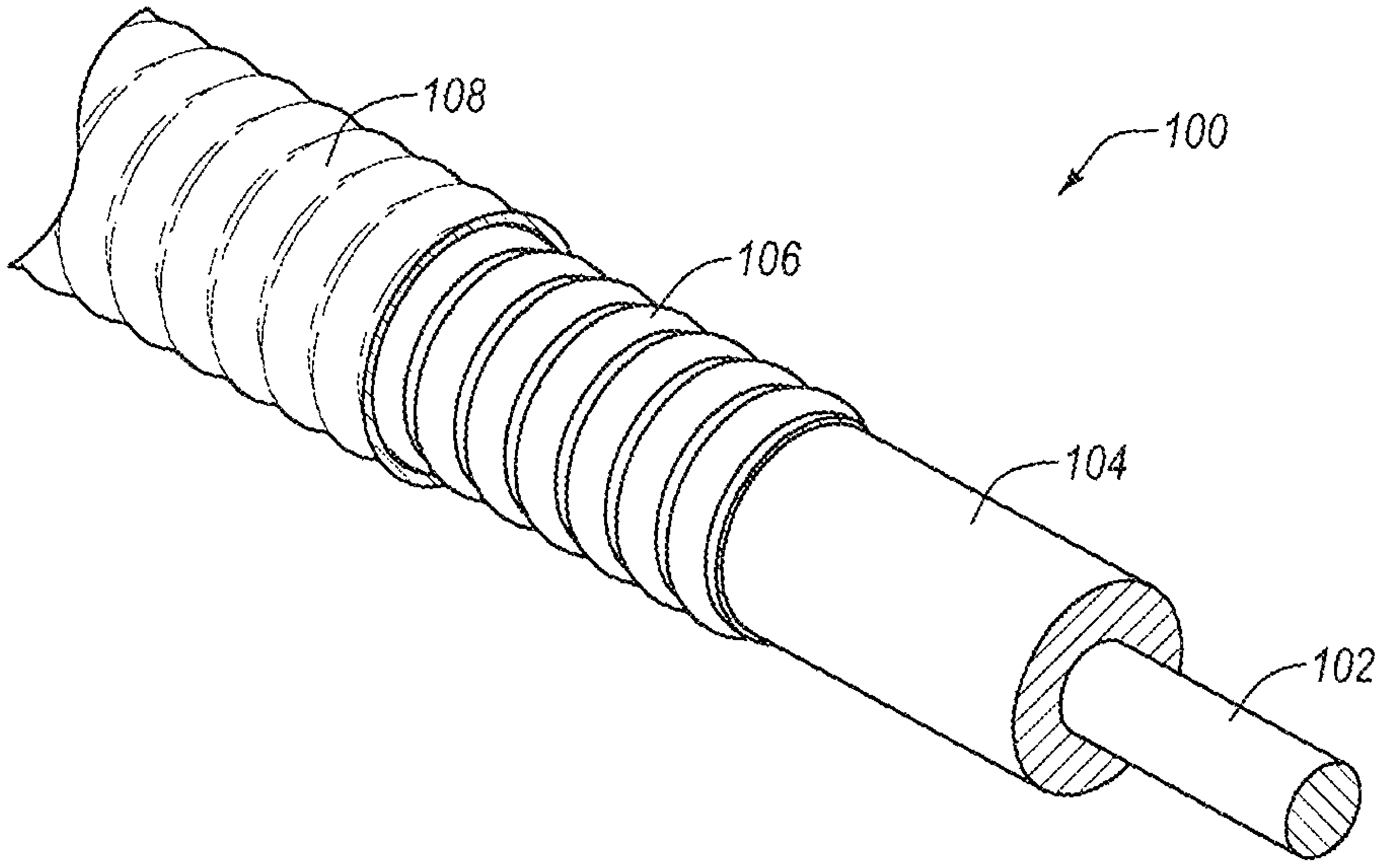


Fig. 1A



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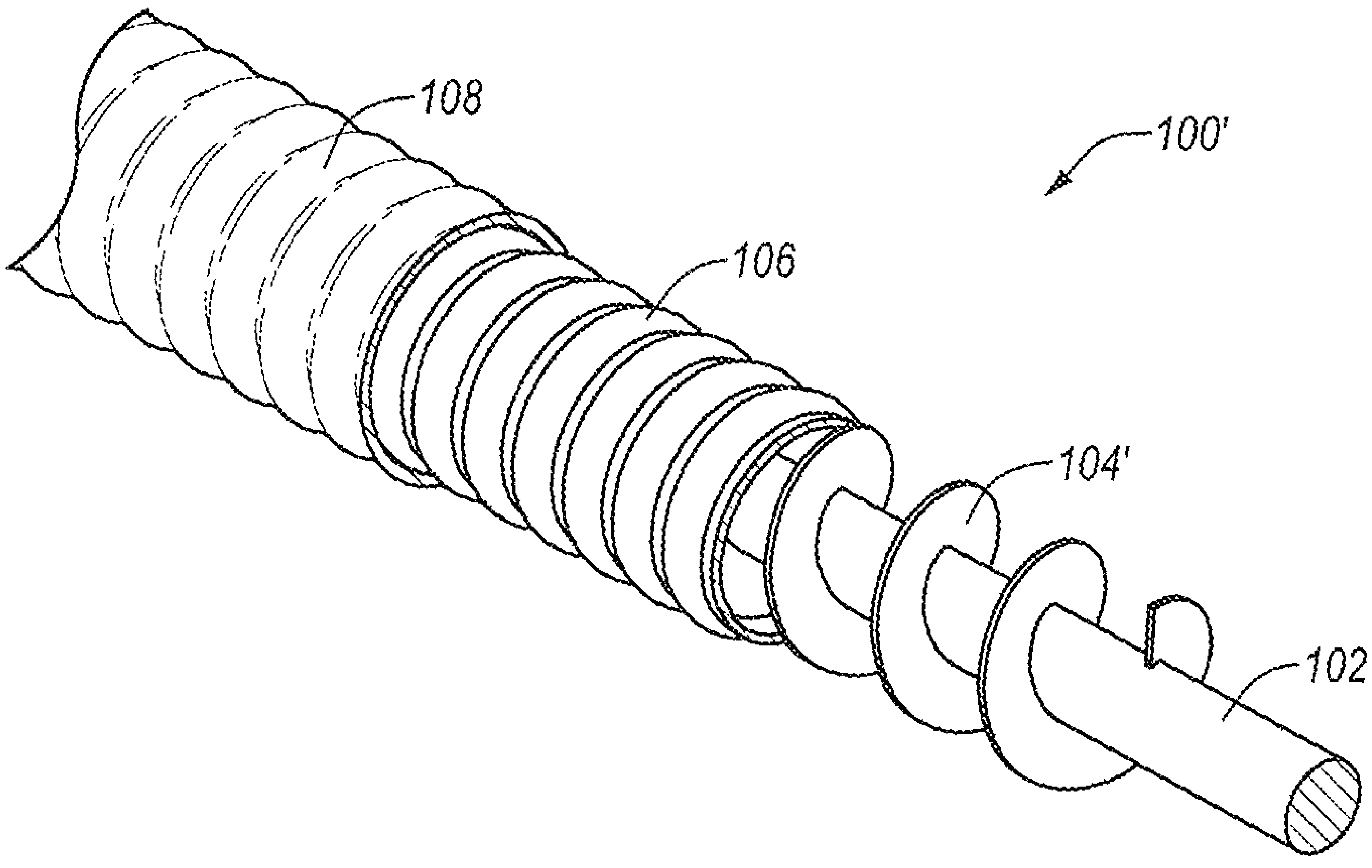

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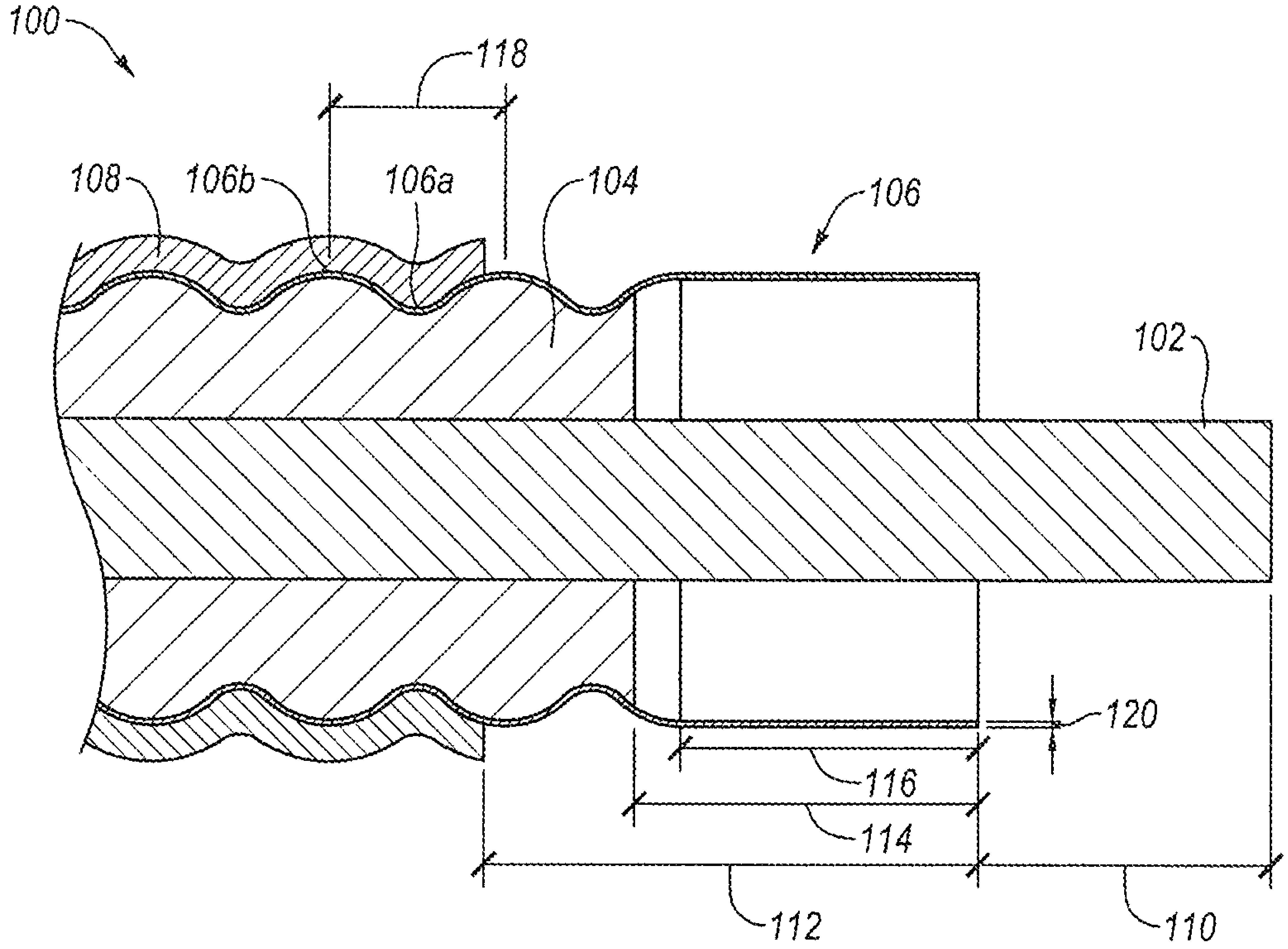

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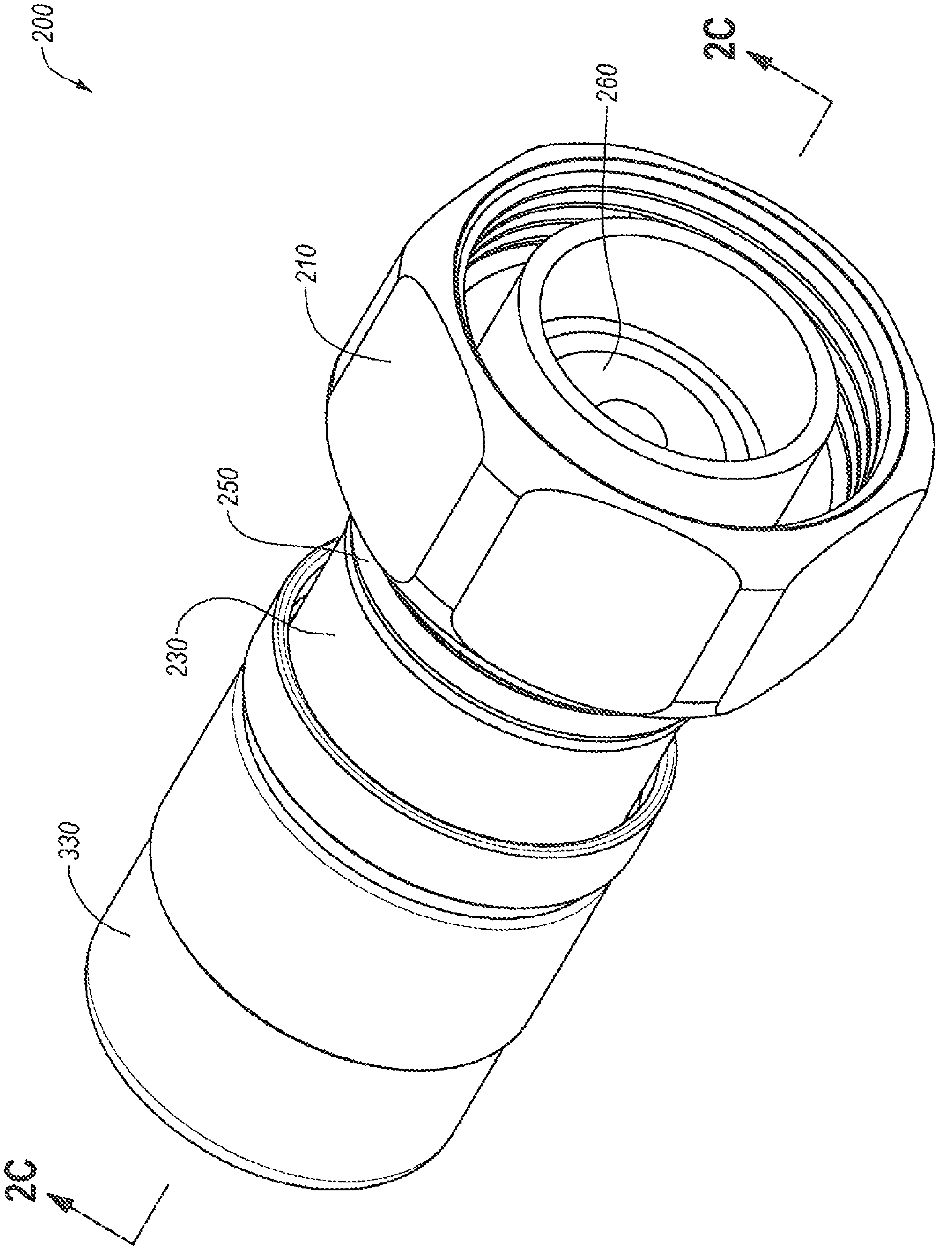

Fig. 2A

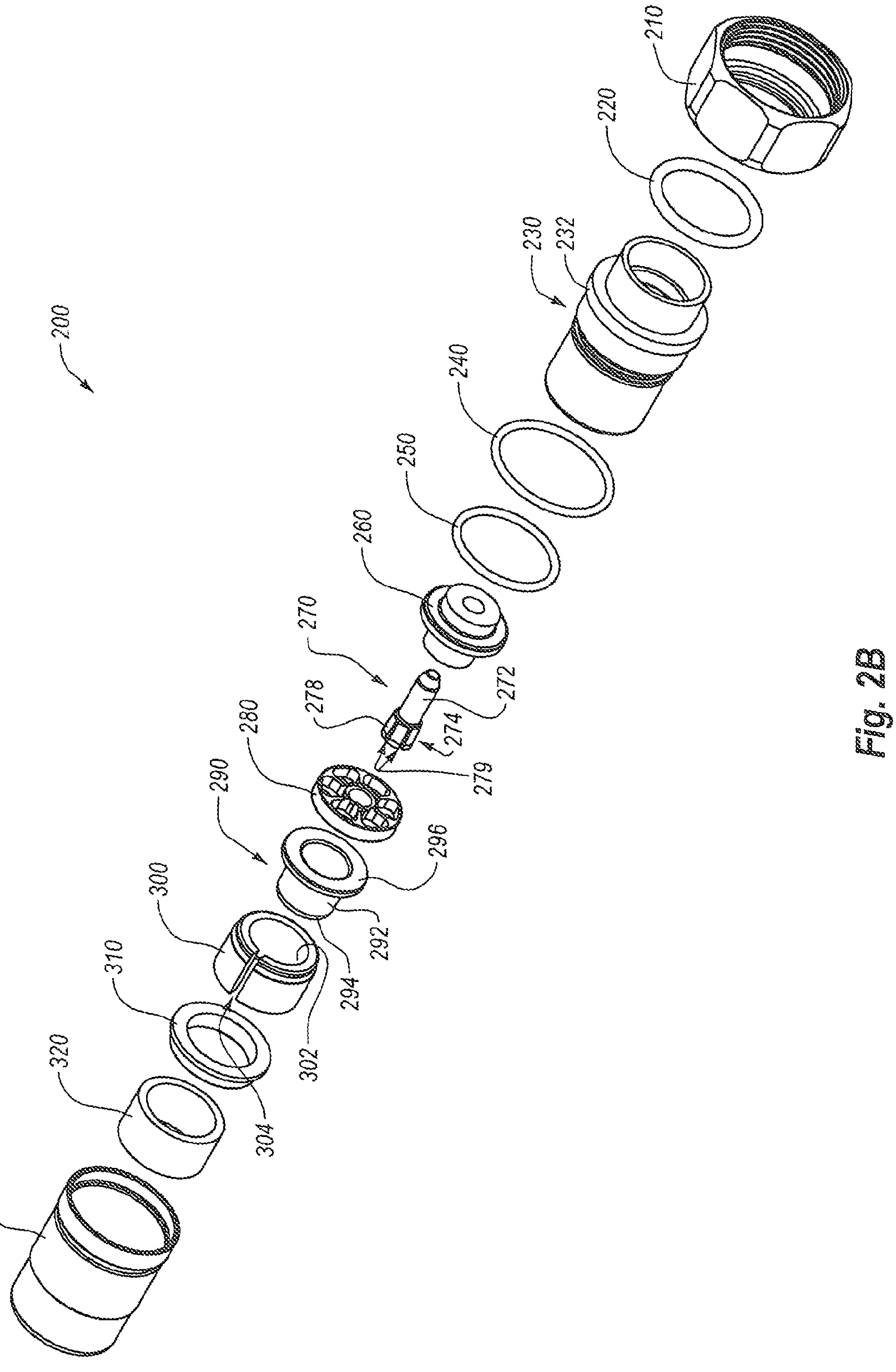
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Fig. 2B

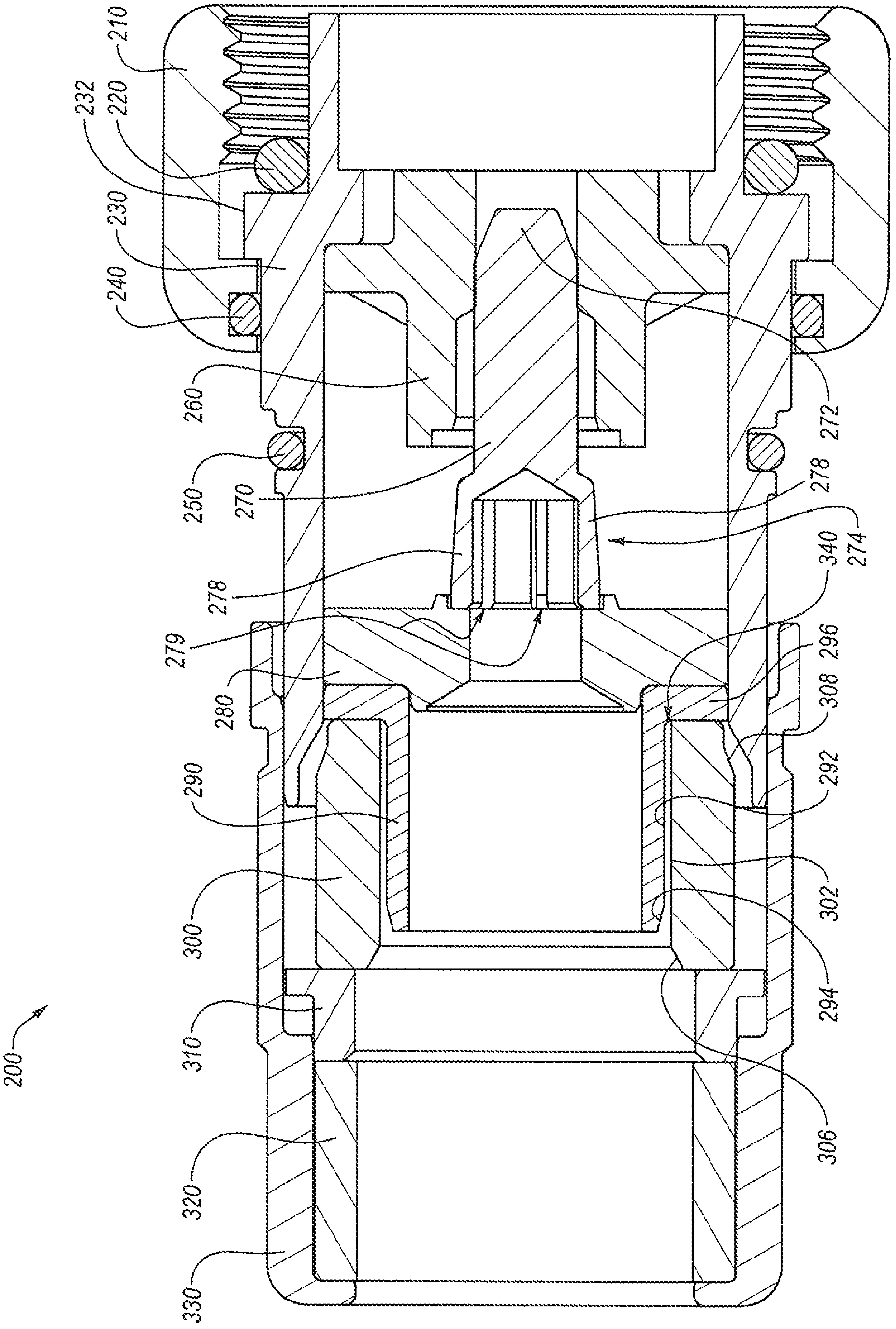
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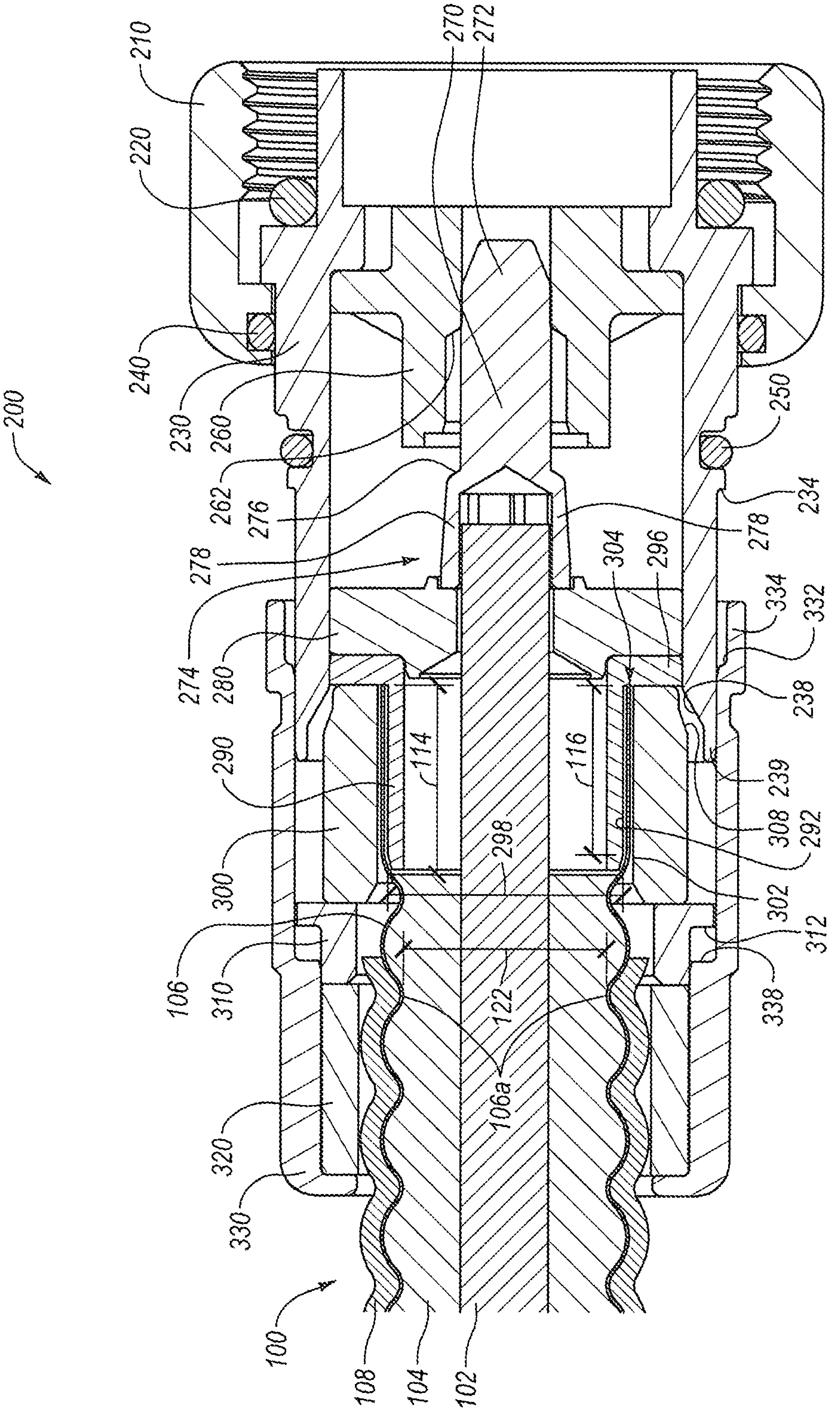
Fig. 2C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106
310
320
330
200
100
108
104
102
270
272
114
116
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106a
304
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238
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292
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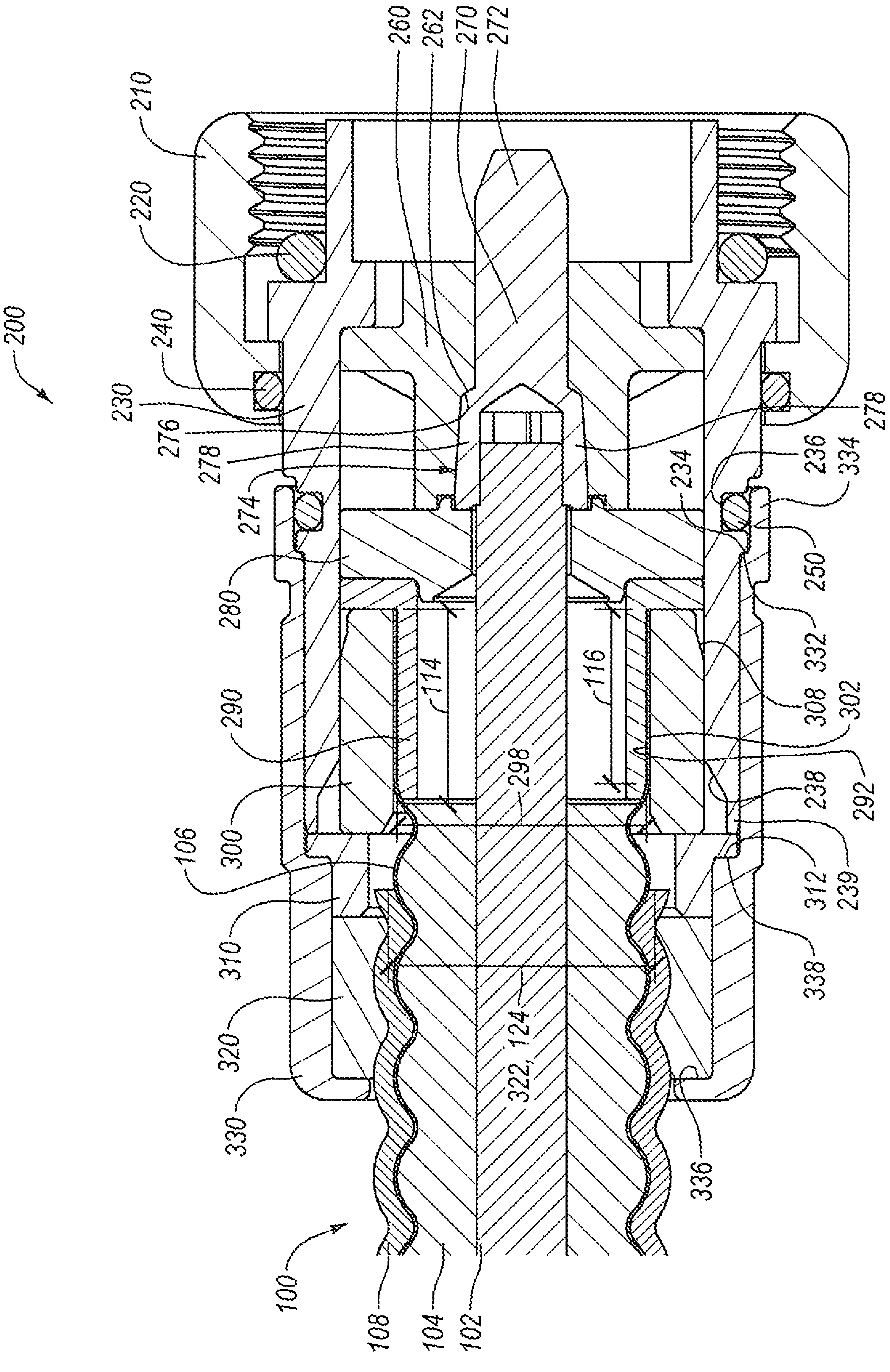
338
250
234
278

Fig. 3A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114
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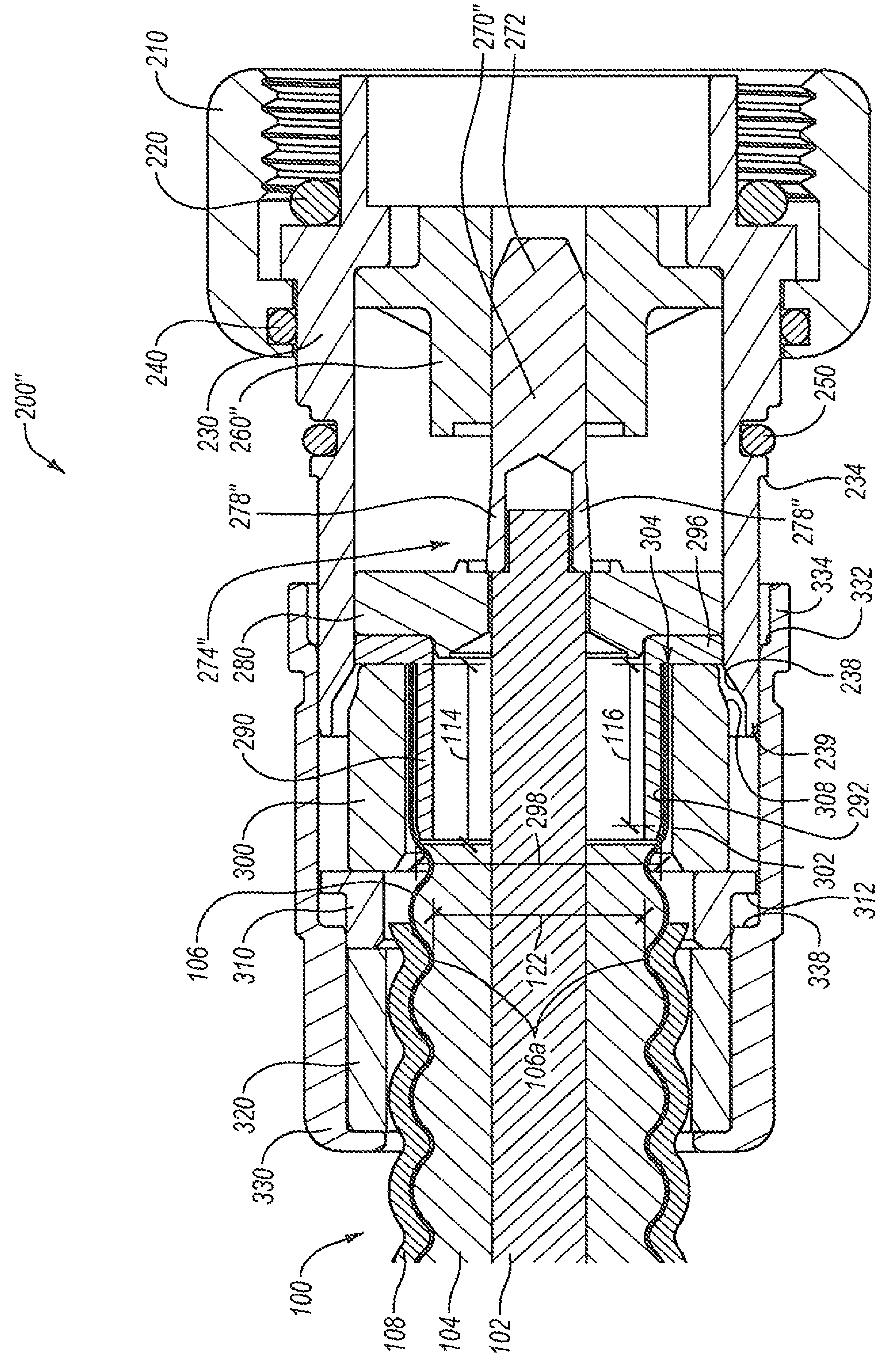
272

Fig. 3B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106a
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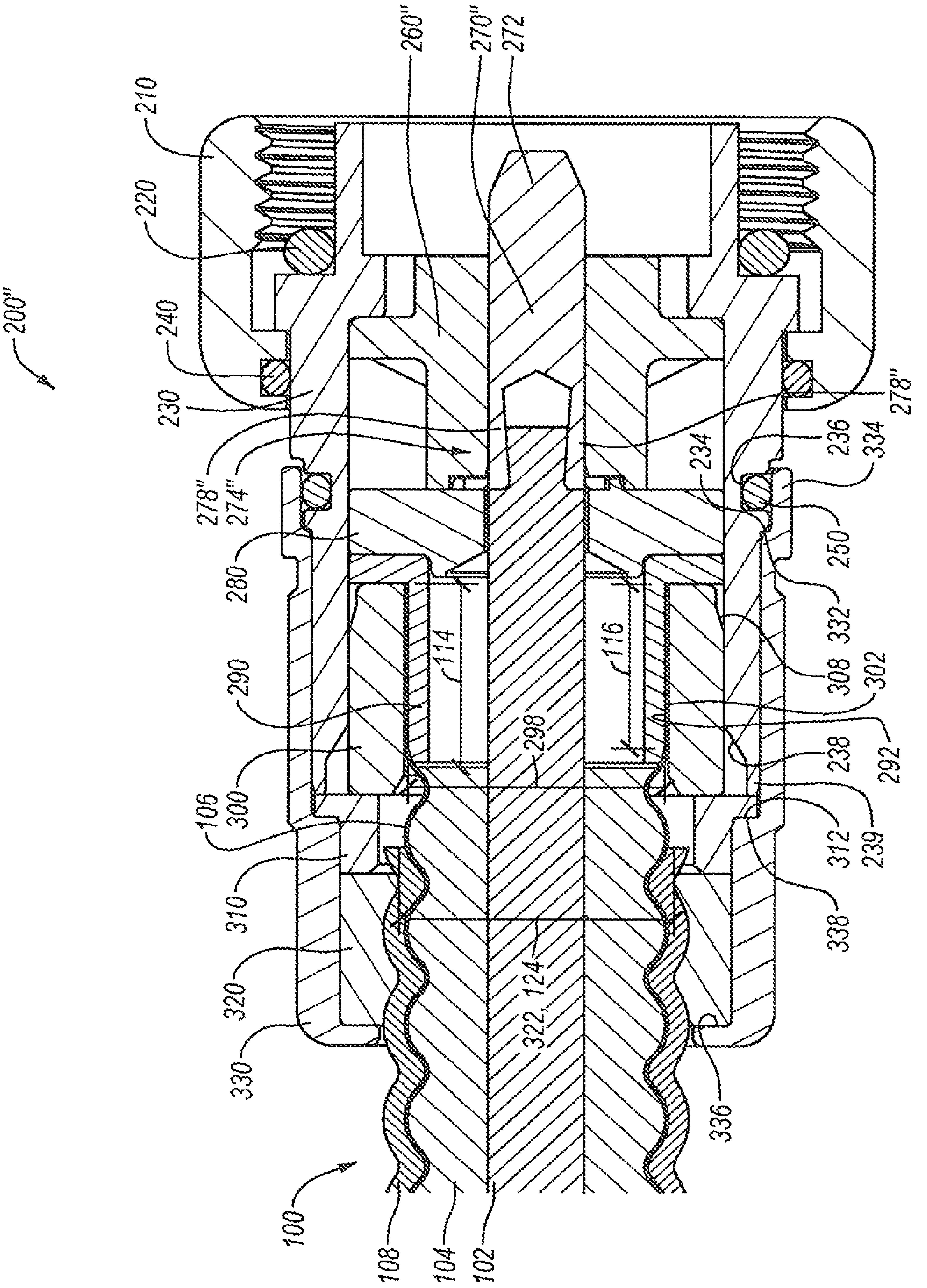
100
108
104
102

Fig. 3C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322, 124
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Fig. 3D

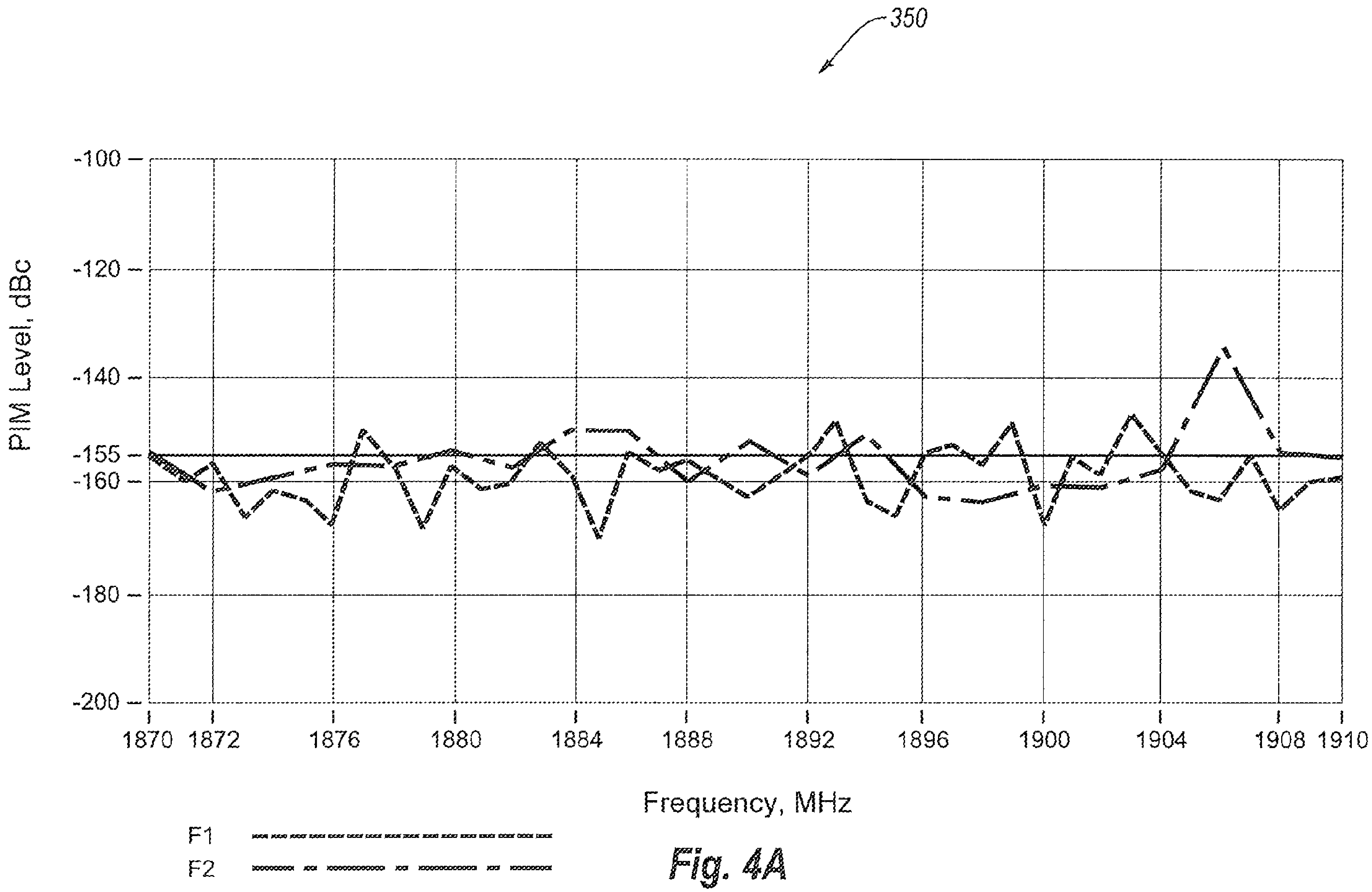


Fig. 4A
(Prior Art)

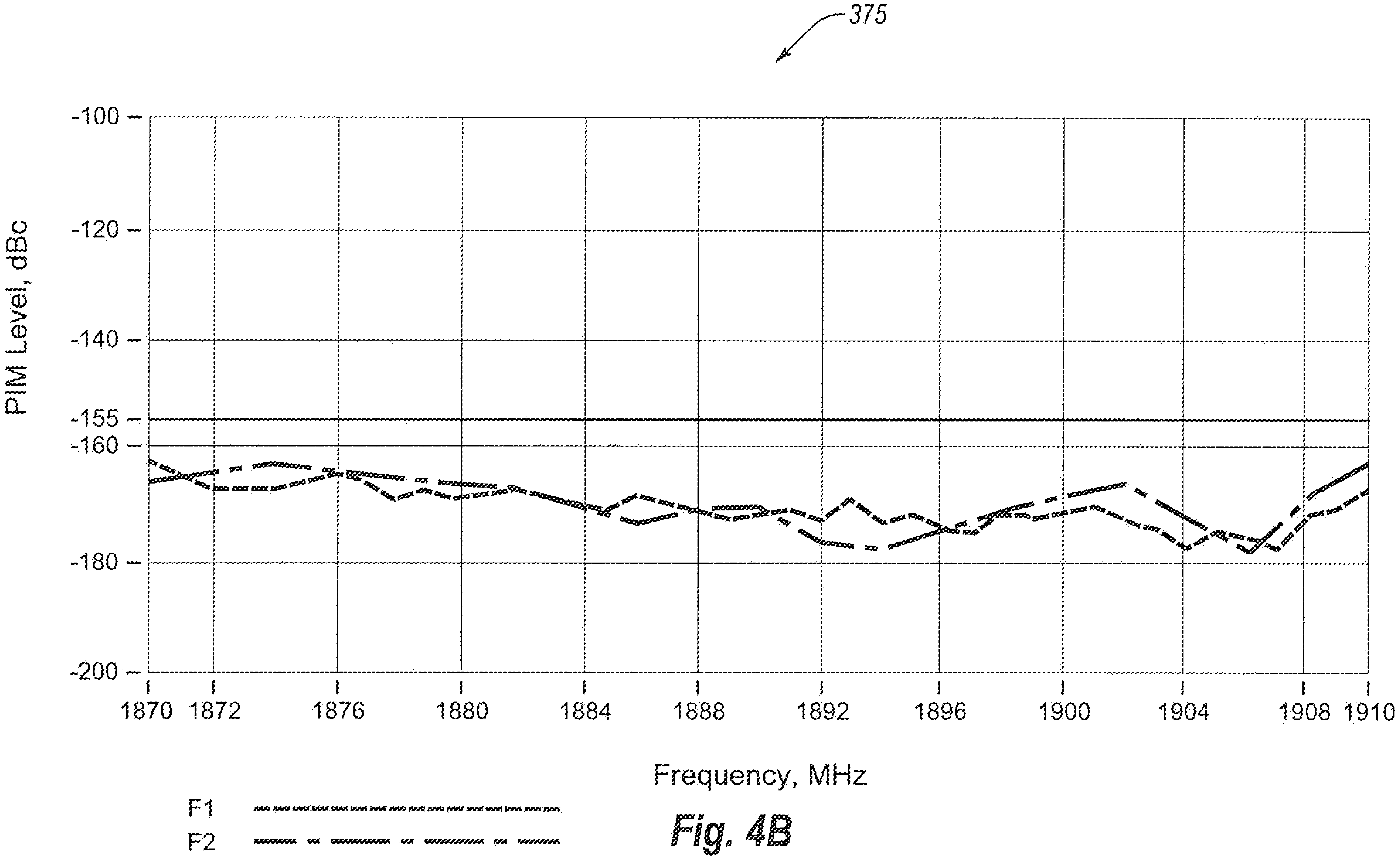

375
PIM Level, dBc
-100
-120
-140
-155
-160
-180
-200
1870
1872
1876
1880
1884
1888
1892
1896
1900
1904
1908
1910
Frequency, MHz
F1
F2

Fig. 4B

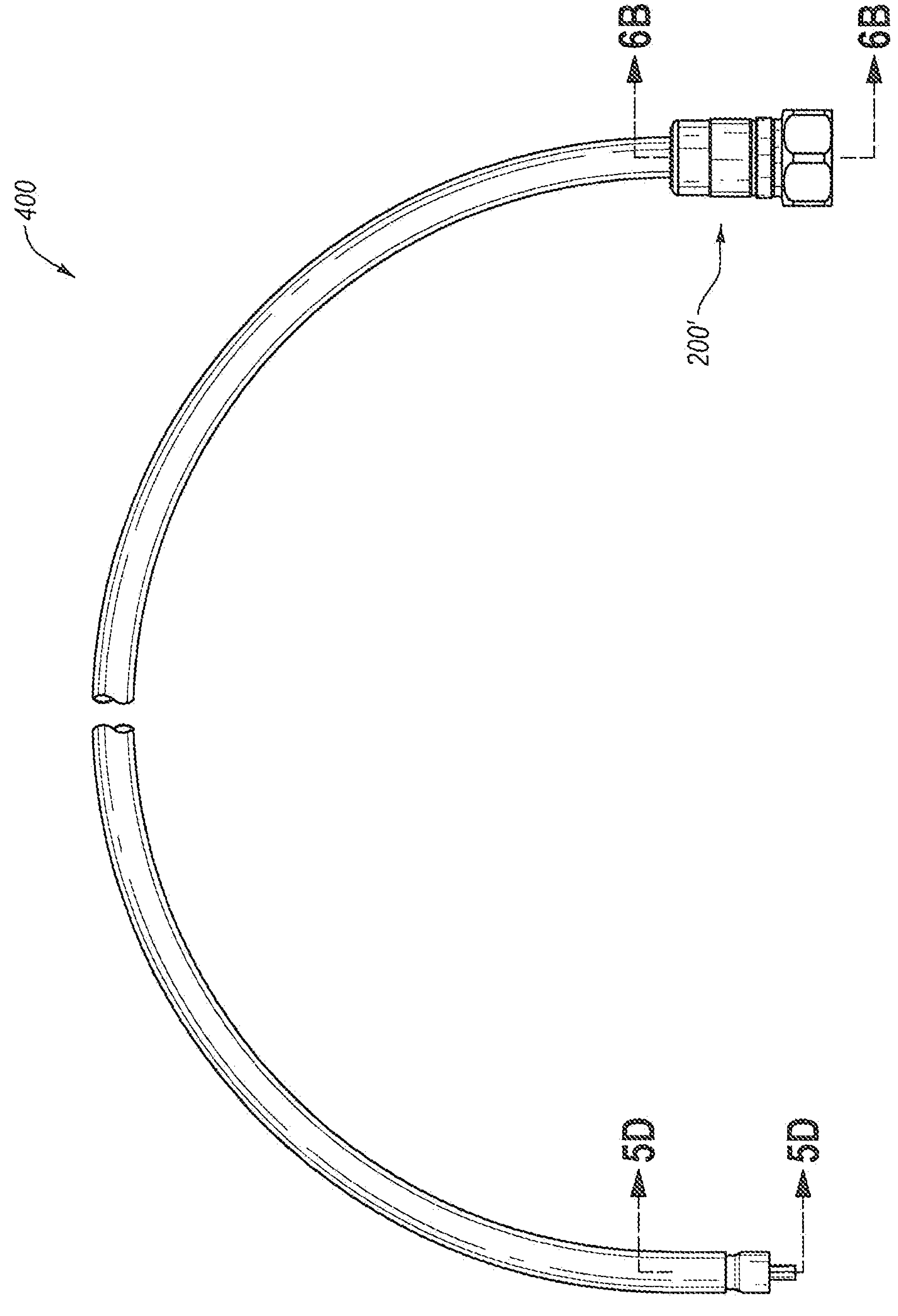


Fig. 5A

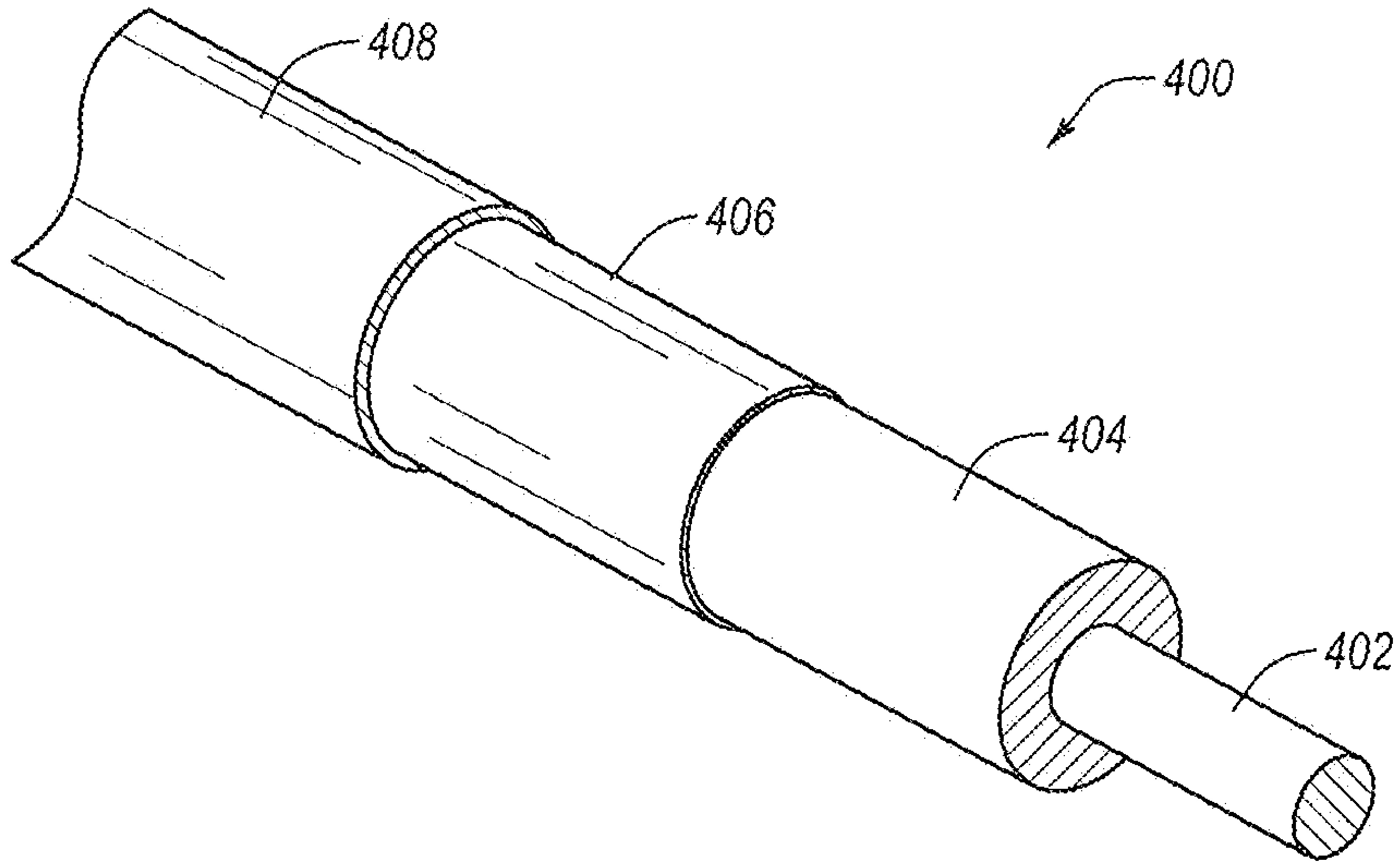


Fig. 5B

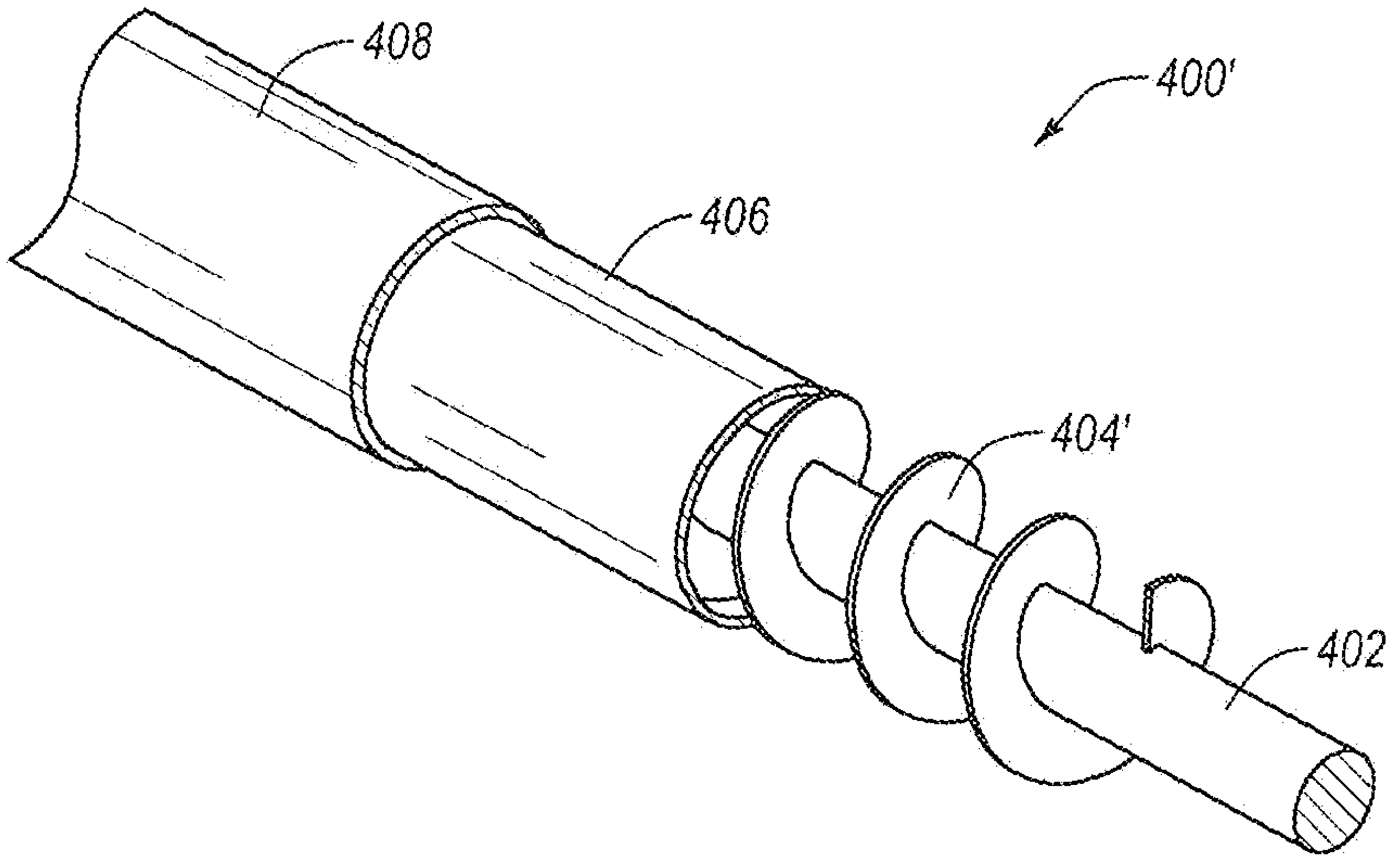


Fig. 5C

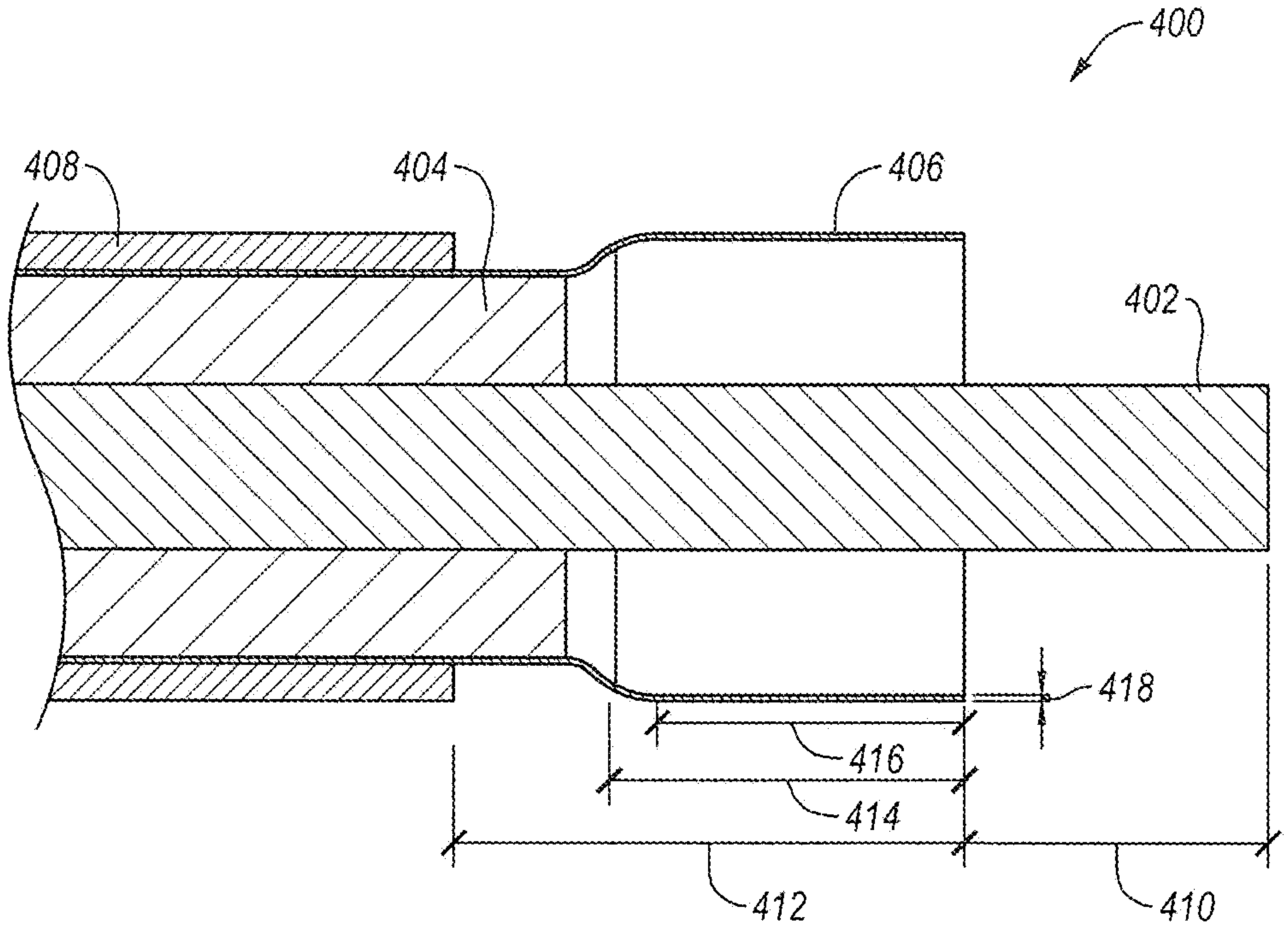
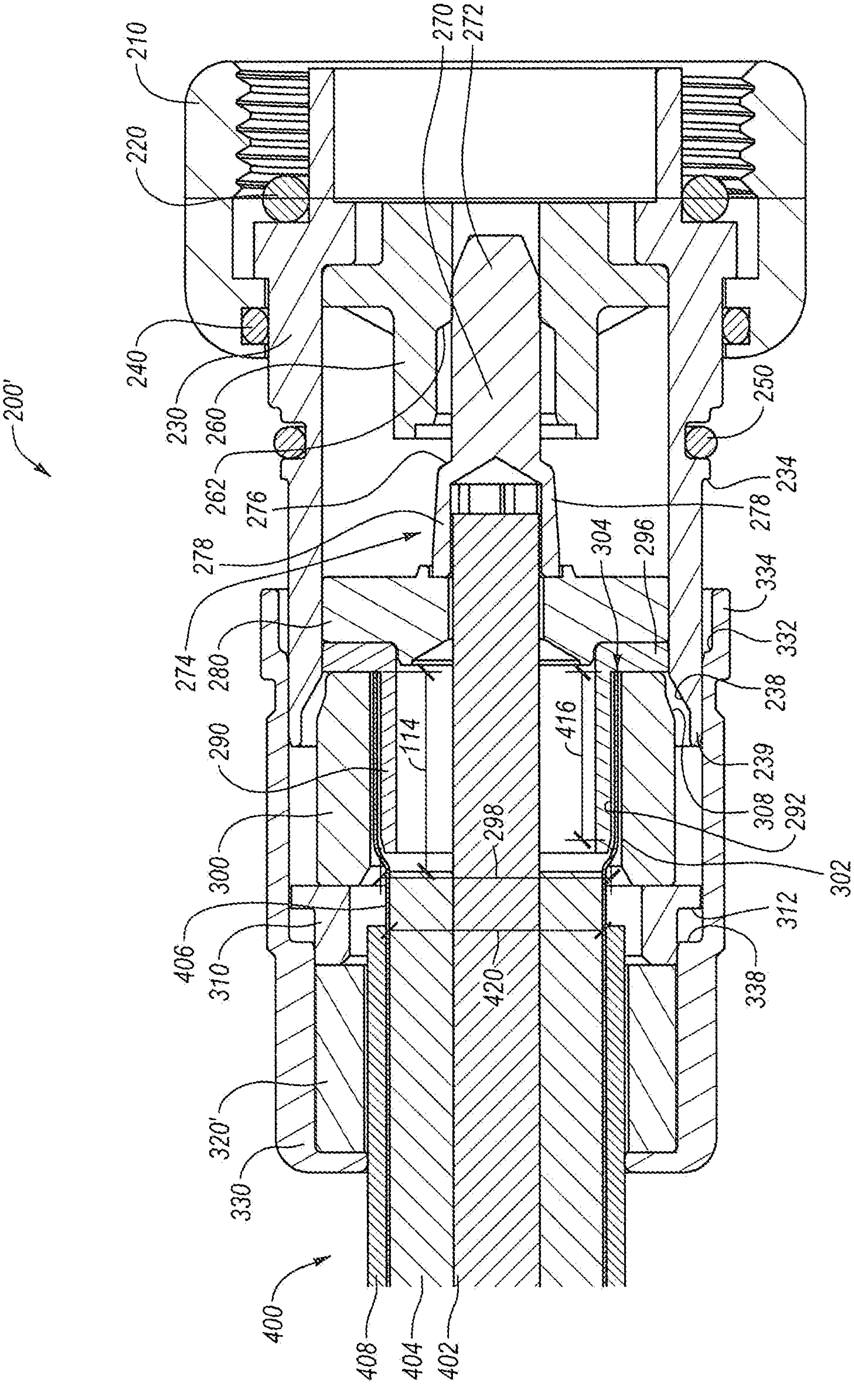


Fig. 5D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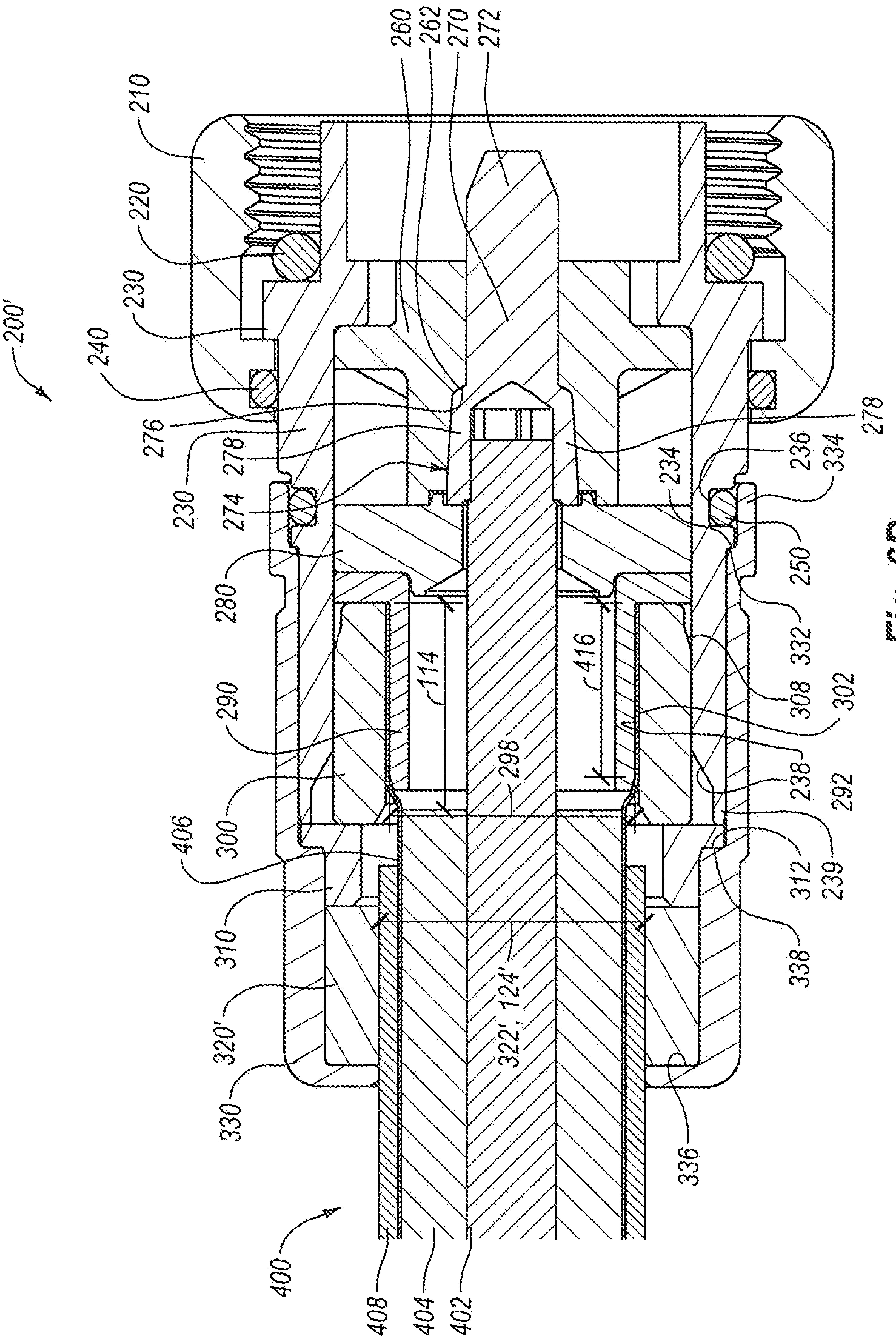
338
416
114
298
420

Fig. 6A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334
234
250
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322', 124'
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402

Fig. 6B

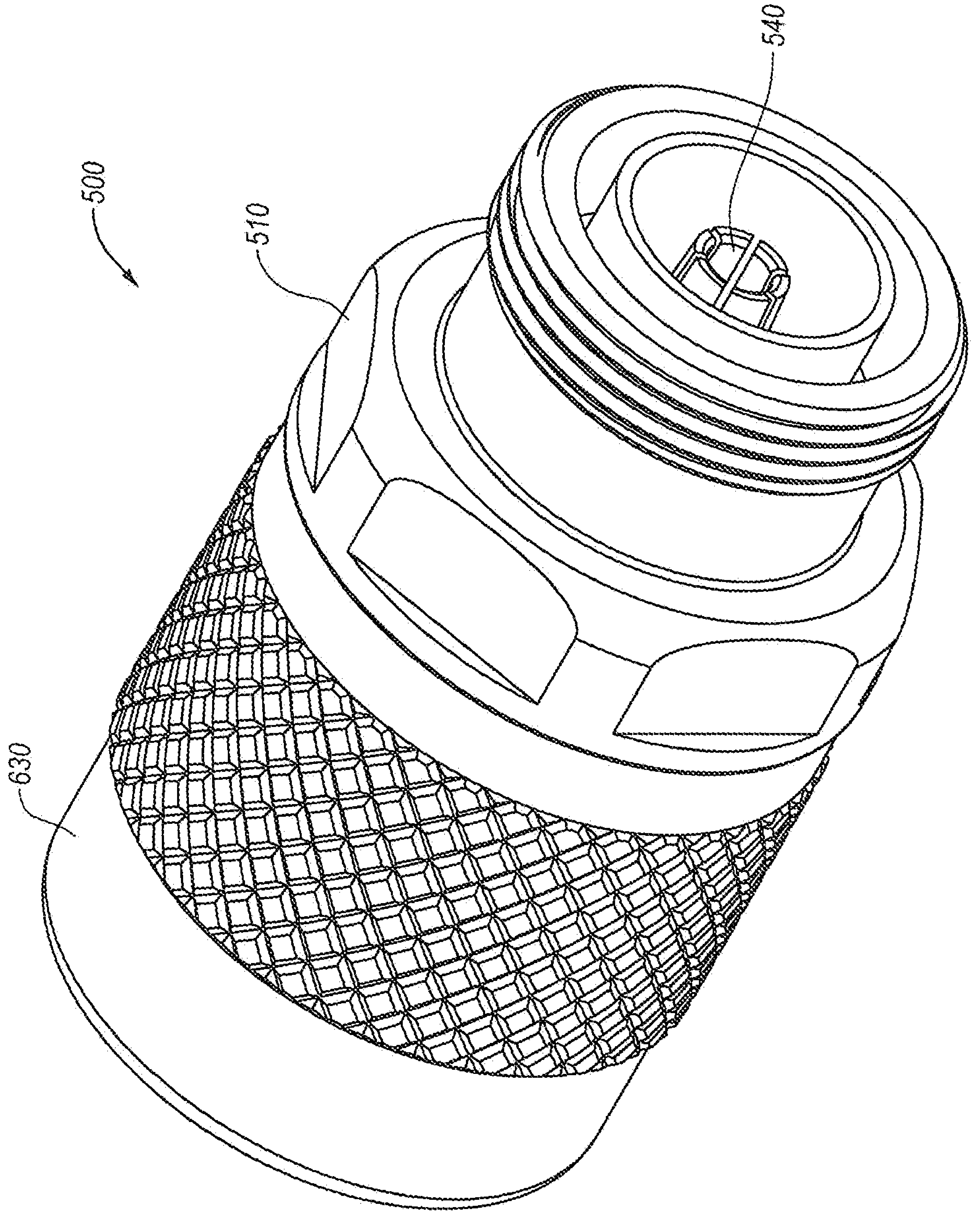

Fig. 7A

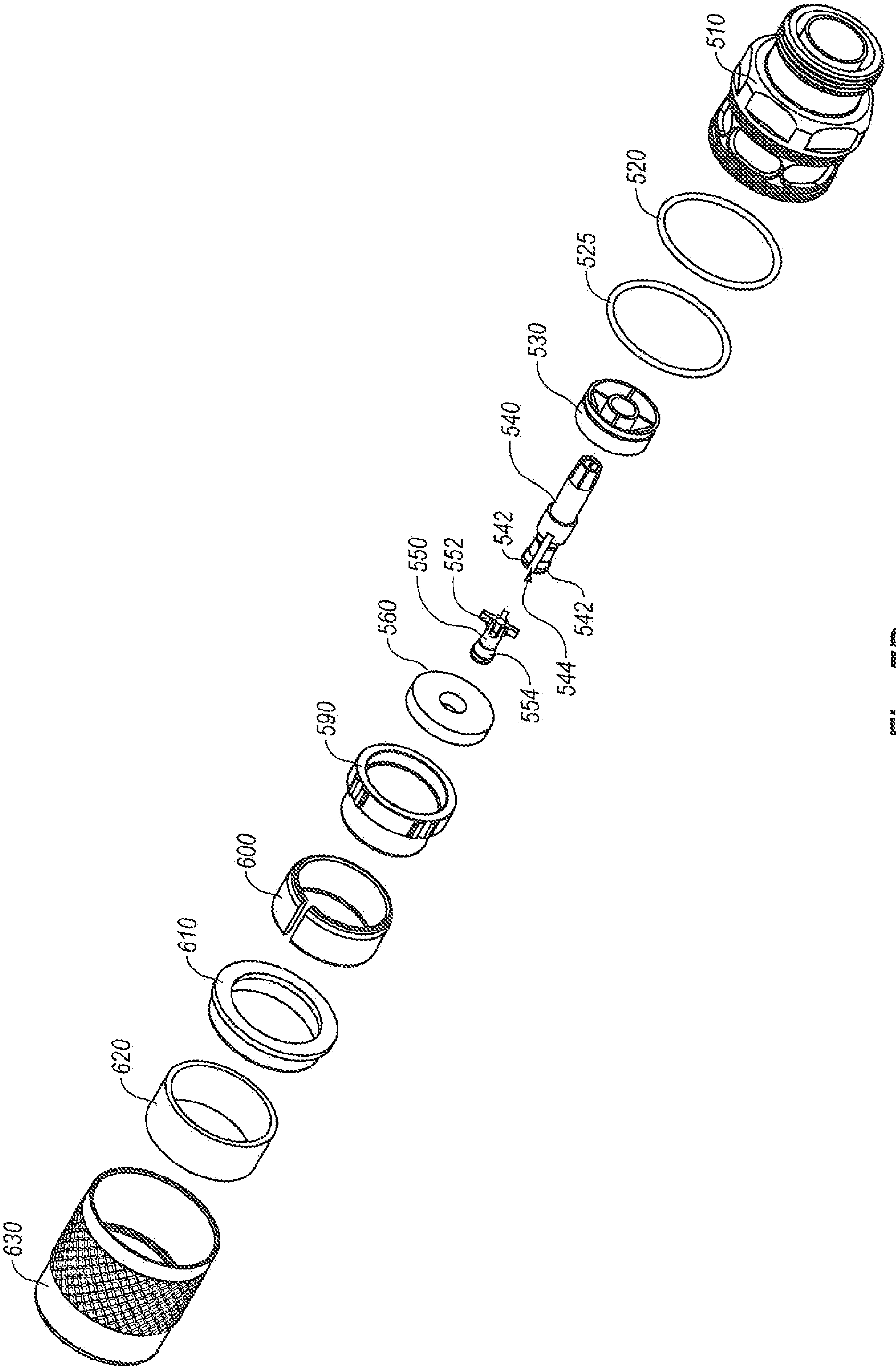
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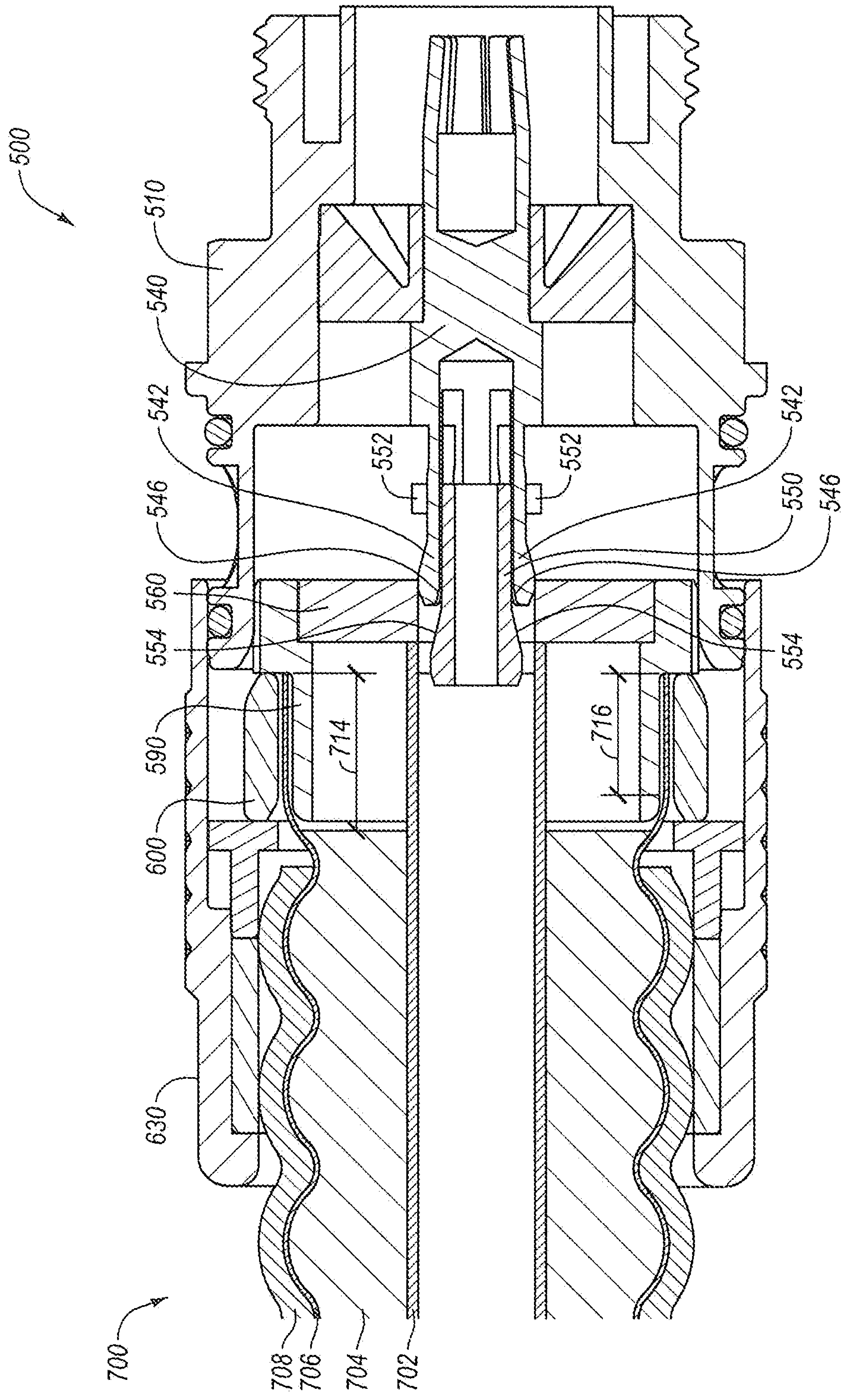
Fig. 7B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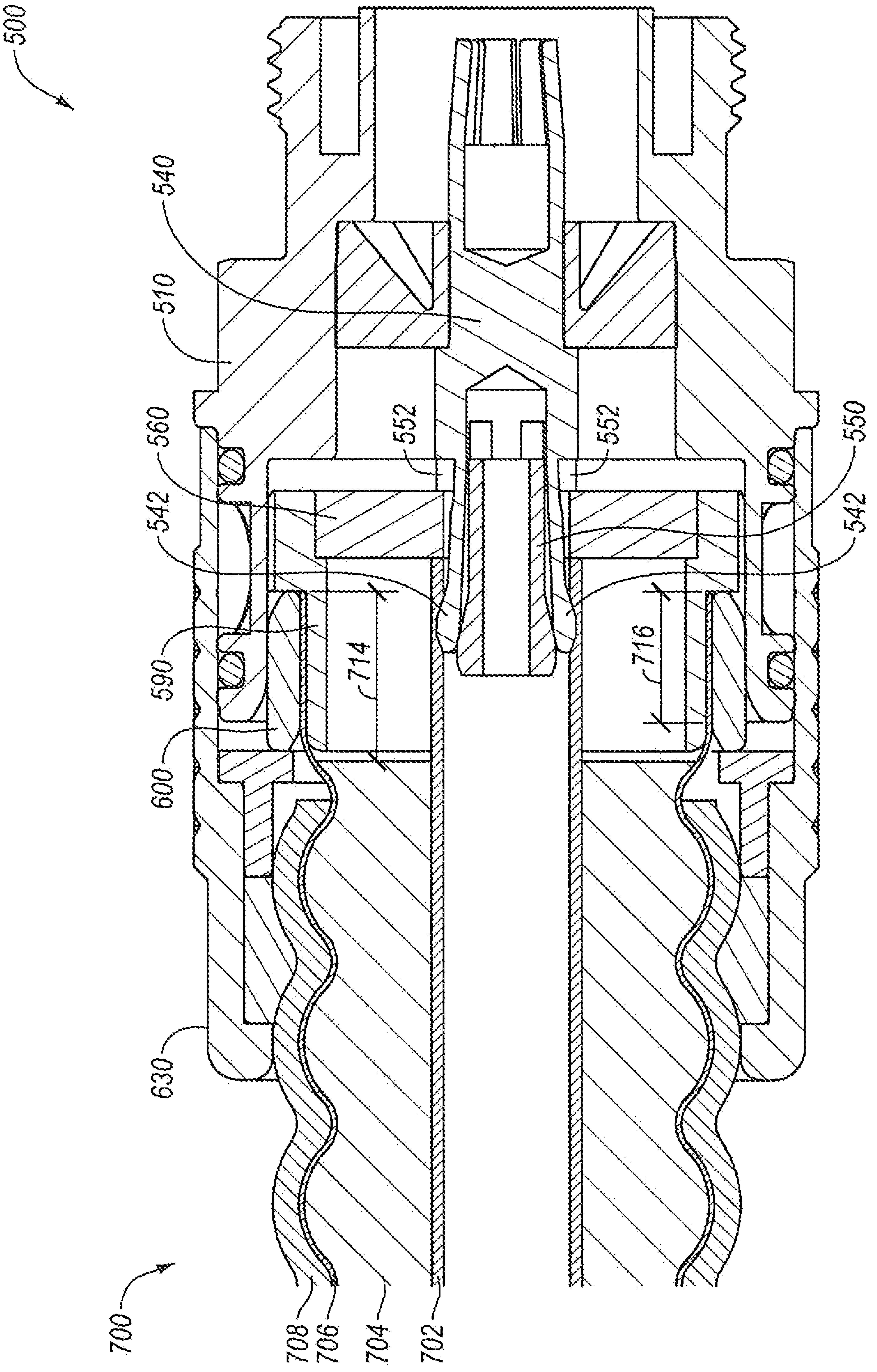
702

Fig. 7C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704
702

Fig. 7D

COAXIAL CABLE CONNECTOR

PRIORITY CLAIM

This application is a continuation of, and claims the benefit and priority of, U.S. patent application Ser. No. 13/784,499, filed on Mar. 4, 2013, which is a continuation of, and claims the benefit and priority of, U.S. patent application Ser. No. 13/093,937, filed on Apr. 26, 2011, now U.S. Pat. No. 8,388,375, which is a continuation of, and claims the benefit and priority of, U.S. patent application Ser. No. 12/753,735, filed on Apr. 2, 2010, now U.S. Pat. No. 7,934,954. The entire contents of such applications are hereby incorporated by reference.

BACKGROUND

Coaxial cable is used to transmit radio frequency (RF) signals in various applications, such as connecting radio transmitters and receivers with their antennas, computer network connections, and distributing cable television signals. Coaxial cable typically comprises an inner conductor, an insulating layer surrounding the inner conductor, an outer conductor surrounding the insulating layer, and a protective jacket surrounding the outer conductor.

Each type of coaxial cable has a characteristic impedance which is the opposition to signal flow in the coaxial cable. The impedance of a coaxial cable depends on its dimensions and the materials used in its manufacture. For example, a coaxial cable can be tuned to a specific impedance by controlling the diameters of the inner and outer conductors and the dielectric constant of the insulating layer. All of the components of a coaxial system should have the same impedance in order to reduce internal reflections at connections between components. Such reflections increase signal loss and can result in the reflected signal reaching a receiver with a slight delay from the original.

Two sections of a coaxial cable in which it can be difficult to maintain a consistent impedance are the terminal sections on either end of the cable to which connectors are attached. For example, the attachment of some field-installable compression connectors requires the removal of a section of the insulating layer at the terminal end of the coaxial cable in order to insert a support structure of the compression connector between the inner conductor and the outer conductor. The support structure of the compression connector prevents the collapse of the outer conductor when the compression connector applies pressure to the outside of the outer conductor. Unfortunately, however, the dielectric constant of the support structure often differs from the dielectric constant of the insulating layer that the support structure replaces, which changes the impedance of the terminal ends of the coaxial cable. This change in the impedance at the terminal ends of the coaxial cable causes increased internal reflections, which results in increased signal loss.

Another difficulty with field-installable connectors, such as compression connectors or screw-together connectors, is maintaining acceptable levels of passive intermodulation (PIM). PIM in the terminal sections of a coaxial cable can result from nonlinear and insecure contact between surfaces of various components of the connector. A nonlinear contact between two or more of these surfaces can cause micro arcing or corona discharge between the surfaces, which can result in the creation of interfering RF signals. For example, some screw-together connectors are designed such that the contact force between the connector and the outer conductor is dependent on a continuing axial holding force of threaded components of the connector. Over time, the threaded components of the connector can inadvertently separate, thus resulting in nonlinear and insecure contact between the connector and the outer conductor.

Where the coaxial cable is employed on a cellular communications tower, for example, unacceptably high levels of PIM in terminal sections of the coaxial cable and resulting interfering RF signals can disrupt communication between sensitive receiver and transmitter equipment on the tower and lower powered cellular devices. Disrupted communication can result in dropped calls or severely limited data rates, for example, which can result in dissatisfied customers and customer churn.

Current attempts to solve these difficulties with field-installable connectors generally consist of employing a pre-fabricated jumper cable having a standard length and having factory-installed soldered or welded connectors on either end. These soldered or welded connectors generally exhibit stable impedance matching and PIM performance over a wider range of dynamic conditions than current field-installable connectors. These pre-fabricated jumper cables are inconvenient, however, in many applications.

For example, each particular cellular communication tower in a cellular network generally requires various custom lengths of coaxial cable, necessitating the selection of various standard-length jumper cables that is each generally longer than needed, resulting in wasted cable. Also, employing a longer length of cable than is needed results in increased insertion loss in the cable. Further, excessive cable length takes up more space on the tower. Moreover, it can be inconvenient for an installation technician to have several lengths of jumper cable on hand instead of a single roll of cable that can be cut to the needed length. Also, factory testing of factory-installed soldered or welded connectors for compliance with impedance matching and PIM standards often reveals a relatively high percentage of noncompliant connectors. This percentage of non-compliant, and therefore unusable, connectors can be as high as about ten percent of the connectors in some manufacturing situations. For all these reasons, employing factory-installed soldered or welded connectors on standard-length jumper cables to solve the above-noted difficulties with field-installable connectors is not an ideal solution.

SUMMARY OF SOME EXAMPLE EMBODIMENTS

In general, example embodiments of the present invention relate to coaxial cable connectors. The example coaxial cable connectors disclosed herein improve impedance matching in coaxial cable terminations, thus reducing internal reflections and resulting signal loss associated with inconsistent impedance. Further, the example coaxial cable connectors disclosed herein also improve mechanical and electrical contacts in coaxial cable terminations, which reduces passive intermodulation (PIM) levels and associated creation of interfering RF signals that emanate from the coaxial cable terminations.

In one example embodiment, a coaxial cable connector for terminating a coaxial cable is provided. The coaxial cable comprises an inner conductor, an insulating layer surrounding the inner conductor, an outer conductor surrounding the insulating layer, and a jacket surrounding the outer conductor. The coaxial cable connector comprises an internal connector structure, an external connector structure, and a conductive pin. The external connector structure cooperates with the internal connector structure to define a cylindrical gap that is configured to receive an increased-diameter cylindrical section of the outer conductor. As the coaxial cable connector is moved from an open position to an engaged position, the external connector structure is configured to be clamped around the increased-diameter cylindrical section so as to radially compress the increased-diameter cylindrical section between the external connector structure and the internal connector structure. Further, as the coaxial cable connector is moved from an open position to an engaged position, a contact force between the conductive pin and the inner conductor is configured to increase.

In another example embodiment, a connector for terminating a corrugated coaxial cable is provided. The corrugated coaxial cable comprises an inner conductor, an insulating layer surrounding the inner conductor, a corrugated outer conductor having peaks and valleys and surrounding the insulating layer, and a jacket surrounding the corrugated outer conductor. The connector comprises a mandrel, a clamp, and a conductive pin. The mandrel has a cylindrical outside surface with a diameter that is greater than an inside diameter of valleys of the corrugated outer conductor. The clamp has a cylindrical inside surface that surrounds the cylindrical outside surface of the mandrel and cooperates with the mandrel to define a cylindrical gap. The cylindrical gap is configured to receive an increased-diameter cylindrical section of the corrugated outer conductor. As the coaxial cable connector is moved from an open position to an engaged position, the cylindrical inside surface is configured to be clamped around the increased-diameter cylindrical section so as to radially compress the increased-diameter cylindrical section between the clamp and the mandrel. Further, as the coaxial cable connector is moved from an open position to an engaged position, a contact force between the conductive pin and the inner conductor is configured to increase.

In yet another example embodiment, a connector for terminating a smooth-walled coaxial cable is provided. The smooth-walled coaxial cable comprises an inner conductor, an insulating layer surrounding the inner conductor, a smooth-walled outer conductor surrounding the insulating layer, and a jacket surrounding the smooth-walled outer conductor. The connector comprises a mandrel, a clamp, and a conductive pin. The mandrel has a cylindrical outside surface with a diameter that is greater than an inside diameter of the smooth-walled outer conductor. The clamp has a cylindrical inside surface that surrounds the cylindrical outside surface of the mandrel and cooperates with the mandrel to define a cylindrical gap. The cylindrical gap is configured to receive an increased-diameter cylindrical section of the smooth-walled outer conductor. As the coaxial cable connector is moved from an open position to an engaged position, the cylindrical inside surface is configured to be clamped around the increased-diameter cylindrical section so as to radially compress the increased-diameter cylindrical section between the clamp and the mandrel. Further, as the coaxial cable connector is moved from an open position to an engaged position, a contact force between the conductive pin and the inner conductor is configured to increase.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential characteristics of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. Moreover, it is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of example embodiments of the present invention will become apparent from the following detailed description of example embodiments given in conjunction with the accompanying drawings, in which:

FIG. **1**A is a perspective view of an example corrugated coaxial cable terminated on one end with an example compression connector;

FIG. **1**B is a perspective view of a portion of the example corrugated coaxial cable of FIG. **1**A, the perspective view having portions of each layer of the example corrugated coaxial cable cut away;

FIG. **1**C is a perspective view of a portion of an alternative corrugated coaxial cable, the perspective view having portions of each layer of the alternative corrugated coaxial cable cut away;

FIG. **1**D is a cross-sectional side view of a terminal end of the example corrugated coaxial cable of FIG. **1**A after having been prepared for termination with the example compression connector of FIG. **1**A;

FIG. **2**A is a perspective view of the example compression connector of FIG. **1**A;

FIG. **2**B is an exploded view of the example compression connector of FIG. **2**A;

FIG. **2**C is a cross-sectional side view of the example compression connector of FIG. **2**A;

FIG. **3**A is a cross-sectional side view of the terminal end of the example corrugated coaxial cable of FIG. **1**D after having been inserted into the example compression connector of FIG. **2**C, with the example compression connector being in an open position;

FIG. **3**B is a cross-sectional side view of the terminal end of the example corrugated coaxial cable of FIG. **1**D after having been inserted into the example compression connector of FIG. **3**A, with the example compression connector being in an engaged position;

FIG. **3**C is a cross-sectional side view of the terminal end of the example corrugated coaxial cable of FIG. **1**D after having been inserted into another example compression, with the example compression connector being in an open position;

FIG. **3**D is a cross-sectional side view of the terminal end of the example corrugated coaxial cable of FIG. **1**D after having been inserted into the example compression connector of FIG. **3**C, with the example compression connector being in an engaged position;

FIG. **4**A is a chart of passive intermodulation (PIM) in a prior art coaxial cable compression connector;

FIG. **4**B is a chart of PIM in the example compression connector of FIG. **3**B;

FIG. **5**A is a perspective view of an example smooth-walled coaxial cable terminated on one end with another example compression connector;

FIG. **5**B is a perspective view of a portion of the example smooth-walled coaxial cable of FIG. **5**A, the perspective view having portions of each layer of the coaxial cable cut away;

FIG. **5**C is a perspective view of a portion of an alternative smooth-walled coaxial cable, the perspective view having portions of each layer of the alternative coaxial cable cut away;

FIG. **5**D is a cross-sectional side view of a terminal end of the example smooth-walled coaxial cable of FIG. **5**A after having been prepared for termination with the example compression connector of FIG. **5**A;

FIG. **6**A is a cross-sectional side view of the terminal end of the example smooth-walled coaxial cable of FIG. **5**D after having been inserted into the example compression connector of FIG. **5**A, with the example compression connector being in an open position;

FIG. **6**B is a cross-sectional side view of the terminal end of the example smooth-walled coaxial cable of FIG. **5**D after having been inserted into the example compression connector of FIG. **6**A, with the example compression connector being in an engaged position;

FIG. **7**A is a perspective view of another example compression connector;

FIG. **7**B is an exploded view of the example compression connector of FIG. **7**A;

FIG. **7**C is a cross-sectional side view of the example compression connector of FIG. **7**A after having a terminal end of another example corrugated coaxial cable inserted into the example compression connector, with the example compression connector being in an open position; and

FIG. **7**D is a cross-sectional side view of the example compression connector of FIG. **7**A after having the terminal end of the example corrugated coaxial cable of FIG. **7**C inserted into the example compression connector, with the example compression connector being in an engaged position.

DETAILED DESCRIPTION OF SOME EXAMPLE EMBODIMENTS

Example embodiments of the present invention relate to coaxial cable connectors. In the following detailed description of some example embodiments, reference will now be made in detail to example embodiments of the present invention which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical and electrical changes may be made without departing from the scope of the present invention. Moreover, it is to be understood that the various embodiments of the invention, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described in one embodiment may be included within other embodiments. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

I. Example Coaxial Cable and Example Compression Connector

With reference now to FIG. **1**A, a first example coaxial cable **100** is disclosed. The example coaxial cable **100** has 50 Ohms of impedance and is a ½" series corrugated coaxial cable. It is understood, however, that these cable characteristics are example characteristics only, and that the example compression connectors disclosed herein can also benefit coaxial cables with other impedance, dimension, and shape characteristics.

Also disclosed in FIG. **1**A, the example coaxial cable **100** is terminated on the right side of FIG. **1**A with an example compression connector **200**. Although the example compression connector **200** is disclosed in FIG. **1**A as a male compression connector, it is understood that the compression connector **200** can instead be configured as a female compression connector (not shown).

With reference now to FIG. **1**B, the coaxial cable **100** generally comprises an inner conductor **102** surrounded by an insulating layer **104**, a corrugated outer conductor **106** surrounding the insulating layer **104**, and a jacket **108** surrounding the corrugated outer conductor **106**. As used herein, the phrase “surrounded by” refers to an inner layer generally being encased by an outer layer. However, it is understood that an inner layer may be “surrounded by” an outer layer without the inner layer being immediately adjacent to the outer layer. The term “surrounded by” thus allows for the possibility of intervening layers. Each of these components of the example coaxial cable **100** will now be discussed in turn.

The inner conductor **102** is positioned at the core of the example coaxial cable **100** and may be configured to carry a range of electrical current (amperes) and/or RF/electronic digital signals. The inner conductor **102** can be formed from copper, copper-clad aluminum (CCA), copper-clad steel (CCS), or silver-coated copper-clad steel (SCCCS), although other conductive materials are also possible. For example, the inner conductor **102** can be formed from any type of conductive metal or alloy. In addition, although the inner conductor **102** of FIG. **1**B is clad, it could instead have other configurations such as solid, stranded, corrugated, plated, or hollow, for example.

The insulating layer **104** surrounds the inner conductor **102**, and generally serves to support the inner conductor **102** and insulate the inner conductor **102** from the outer conductor **106**. Although not shown in the figures, a bonding agent, such as a polymer, may be employed to bond the insulating layer **104** to the inner conductor **102**. As disclosed in FIG. **1**B, the insulating layer **104** is formed from a foamed material such as, but not limited to, a foamed polymer or fluoropolymer. For example, the insulating layer **104** can be formed from foamed polyethylene (PE).

The corrugated outer conductor **106** surrounds the insulating layer **104**, and generally serves to minimize the ingress and egress of high frequency electromagnetic radiation to/from the inner conductor **102**. In some applications, high frequency electromagnetic radiation is radiation with a frequency that is greater than or equal to about 50 MHz. The corrugated outer conductor **106** can be formed from solid copper, solid aluminum, copper-clad aluminum (CCA), although other conductive materials are also possible. The corrugated configuration of the corrugated outer conductor **106**, with peaks and valleys, enables the coaxial cable **100** to be flexed more easily than cables with smooth-walled outer conductors.

The jacket **108** surrounds the corrugated outer conductor **106**, and generally serves to protect the internal components of the coaxial cable **100** from external contaminants, such as dust, moisture, and oils, for example. In a typical embodiment, the jacket **108** also functions to limit the bending radius of the cable to prevent kinking, and functions to protect the cable (and its internal components) from being crushed or otherwise misshapen from an external force. The jacket **108** can be formed from a variety of materials including, but not limited to, polyethylene (PE), high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), rubberized polyvinyl chloride (PVC), or some combination thereof. The actual material used in the formation of the jacket **108** might be indicated by the particular application/environment contemplated.

It is understood that the insulating layer **104** can be formed from other types of insulating materials or structures having a dielectric constant that is sufficient to insulate the inner conductor **102** from the outer conductor **106**. For example, as disclosed in FIG. **1**C, an alternative coaxial cable **100'** comprises an alternative insulating layer **104'** composed of a spiral-shaped spacer that enables the inner conductor **102** to be generally separated from the corrugated outer conductor

106 by air. The spiral-shaped spacer of the alternative insulating layer **104'** may be formed from polyethylene or polypropylene, for example. The combined dielectric constant of the spiral-shaped spacer and the air in the alternative insulating layer **104'** would be sufficient to insulate the inner conductor **102** from the corrugated outer conductor **106** in the alternative coaxial cable **100'**. Further, the example compression connector **200** disclosed herein can similarly benefit the alternative coaxial cable **100'**.

With reference to FIG. **1**D, a terminal end of the coaxial cable **100** is disclosed after having been prepared for termination with the example compression connector **200**, disclosed in FIGS. **1**A and **2**A-**3**B. As disclosed in FIG. **1**D, the terminal end of the coaxial cable **100** comprises a first section **110**, a second section **112**, a cored-out section **114**, and an increased-diameter cylindrical section **116**. The jacket **108**, corrugated outer conductor **106**, and insulating layer **104** have been stripped away from the first section **110**. The jacket **108** has been stripped away from the second section **112**. The insulating layer **104** has been cored out from the cored out section **114**. The diameter of a portion of the corrugated outer conductor **106** that surrounds the cored-out section **114** has been increased so as to create the increased-diameter cylindrical section **116** of the outer conductor **106**.

The term "cylindrical" as used herein refers to a component having a section or surface with a substantially uniform diameter throughout the length of the section or surface. It is understood, therefore, that a "cylindrical" section or surface may have minor imperfections or irregularities in the roundness or consistency throughout the length of the section or surface. It is further understood that a "cylindrical" section or surface may have an intentional distribution or pattern of features, such as grooves or teeth, but nevertheless on average has a substantially uniform diameter throughout the length of the section or surface.

This increasing of the diameter of the corrugated outer conductor **106** can be accomplished using any of the tools disclosed in co-pending U.S. patent application Ser. No. 12/753,729, titled "COAXIAL CABLE PREPARATION TOOLS," filed Apr. 2, 2010 and incorporated herein by reference in its entirety. Alternatively, this increasing of the diameter of the corrugated outer conductor **106** can be accomplished using other tools, such as a common pipe expander.

As disclosed in FIG. **1**D, the increased-diameter cylindrical section **116** can be fashioned by increasing a diameter of one or more of the valleys **106***a* of the corrugated outer conductor **106** that surround the cored-out section **114**. For example, as disclosed in FIG. **1**D, the diameters of one or more of the valleys **106***a* can be increased until they are equal to the diameters of the peaks **106***b*, resulting in the increased-diameter cylindrical section **116** disclosed in FIG. **1**D. It is understood, however, that the diameter of the increased-diameter cylindrical section **116** of the outer conductor **106** can be greater than the diameter of the peaks **106***b* of the example corrugated coaxial cable **100**. Alternatively, the diameter of the increased-diameter cylindrical section **116** of the outer conductor **106** can be greater than the diameter of the valleys **106***a* but less than the diameter of the peaks **106***b*.

As disclosed in FIG. **1**D, the increased-diameter cylindrical section **116** of the corrugated outer conductor **106** has a substantially uniform diameter throughout the length of the increased-diameter cylindrical section **116**. It is understood that the length of the increased-diameter cylindrical section **116** should be sufficient to allow a force to be directed inward on the increased-diameter cylindrical section **116**, once the corrugated coaxial cable **100** is terminated with the example compression connector **200**, with the inwardly-directed force having primarily a radial component and having substantially no axial component.

As disclosed in FIG. **1**D, the increased-diameter cylindrical section **116** of the corrugated outer conductor **106** has a length greater than the distance **118** spanning the two adjacent peaks **106***b* of the corrugated outer conductor **106**. More particularly, the length of the increased-diameter cylindrical section **116** is thirty three times the thickness **120** of the outer conductor **106**. It is understood, however, that the length of the increased-diameter cylindrical section **116** could be any length from two times the thickness **120** of the outer conductor **106** upward. It is further understood that the tools and/or processes that fashion the increased-diameter cylindrical section **116** may further create increased-diameter portions of the corrugated outer conductor **106** that are not cylindrical.

The preparation of the terminal section of the example corrugated coaxial cable **100** disclosed in FIG. **1**D can be accomplished by employing the example method **400** disclosed in co-pending U.S. patent application Ser. No. 12/753,742, titled "PASSIVE INTERMODULATION AND IMPEDANCE MANAGEMENT IN COAXIAL CABLE TERMINATIONS," filed Apr. 2, 2010 and incorporated herein by reference in its entirety.

Although the insulating layer **104** is shown in FIG. **1**D as extending all the way to the top of the peaks **106***b* of the corrugated outer conductor **106**, it is understood that an air gap may exist between the insulating layer **104** and the top of the peaks **106***b*. Further, although the jacket **108** is shown in the FIG. **1**D as extending all the way to the bottom of the valleys **106***a* of the corrugated outer conductor **106**, it is understood that an air gap may exist between the jacket **108** and the bottom of the valleys **106***a*.

In addition, it is understood that the corrugated outer conductor **106** can be either annular corrugated outer conductor, as disclosed in the figures, or can be helical corrugated outer conductor (not shown). Further, the example compression connectors disclosed herein can similarly benefit a coaxial cable with a helical corrugated outer conductor (not shown).

II. Example Compression Connector

With reference now to FIGS. **2**A-**2**C, additional aspects of the example compression connector **200** are disclosed. As disclosed in FIGS. **2**A-**2**C, the example compression connector **200** comprises a connector nut **210**, a first o-ring seal **220**, a connector body **230**, a second o-ring seal **240**, a third o-ring seal **250**, an insulator **260**, a conductive pin **270**, a driver **280**, a mandrel **290**, a clamp **300**, a clamp ring **310**, a jacket seal **320**, and a compression sleeve **330**.

As disclosed in FIGS. **2**B and **2**C, the connector nut **210** is connected to the connector body **230** via an annular flange **232**. The insulator **260** positions and holds the conductive pin **270** within the connector body **230**. The conductive pin **270** comprises a pin portion **272** at one end and a collet portion **274** at the other end. The collet portion **274** comprises fingers **278** separated by slots **279**. The slots **279** are configured to narrow or close as the compression connector **200** is moved from an open position (as disclosed in FIG. **3**A) to an engaged position (as disclosed in FIG. **3**B), as discussed in greater detail below. The collet portion **274** is configured to receive and surround an inner conductor of a coaxial cable. The driver **280** is positioned inside connector body **230** between the collet portion **274** of the conductive pin **270** and the mandrel **290**. The mandrel **290** abuts the clamp **300**. The clamp **300** abuts the clamp ring **310**, which abuts the jacket seal **320**, both of which are positioned within the compression sleeve **330**.

The mandrel **290** is an example of an internal connector structure as at least a portion of the mandrel **290** is configured to be positioned internal to a coaxial cable. The clamp **300** is an example of an external connector structure as at least a portion of the clamp **300** is configured to be positioned external to a coaxial cable. The mandrel **290** has a cylindrical outside surface **292** that is surrounded by a cylindrical inside surface **302** of the clamp **300**. The cylindrical outside surface **292** cooperates with the cylindrical inside surface **302** to define a cylindrical gap **340**.

The mandrel **290** further has an inwardly-tapering outside surface **294** adjacent to one end of the cylindrical outside surface **292**, as well as an annular flange **296** adjacent to the other end of the cylindrical outside surface **292**. As disclosed in FIG. **2**B, the clamp **300** defines a slot **304** running the length of the clamp **300**. The slot **304** is configured to narrow or close as the compression connector **200** is moved from an open position (as disclosed in FIG. **3**A) to an engaged position (as disclosed in FIG. **3**B), as discussed in greater detail below. Further, as disclosed in FIG. **2**C, the clamp **300** further has an outwardly-tapering surface **306** adjacent to the cylindrical inside surface **302**. Also, the clamp **300** further has an inwardly-tapering outside transition surface **308**.

Although the majority of the outside surface of the mandrel **290** and the inside surface of the clamp **300** are cylindrical, it is understood that portions of these surfaces may be non-cylindrical. For example, portions of these surfaces may include steps, grooves, or ribs in order achieve mechanical and electrical contact with the increased-diameter cylindrical section **116** of the example coaxial cable **100**.

For example, the outside surface of the mandrel **290** may include a rib that corresponds to a cooperating groove included on the inside surface of the clamp **300**. In this example, the compression of the increased-diameter cylindrical section **116** between the mandrel **290** and the clamp **300** will cause the rib of the mandrel **290** to deform the increased-diameter cylindrical section **116** into the cooperating groove of the clamp **300**. This can result in improved mechanical and/or electrical contact between the clamp **300**, the increased-diameter cylindrical section **116**, and the mandrel **290**. In this example, the locations of the rib and the cooperating groove can also be reversed. Further, it is understood that at least portions of the surfaces of the rib and the cooperating groove can be cylindrical surfaces. Also, multiple rib/cooperating groove pairs may be included on the mandrel **290** and/or the clamp **300**. Therefore, the outside surface of the mandrel **290** and the inside surface of the clamp **300** are not limited to the configurations disclosed in the figures.

III. Cable Termination Using the Example Compression Connector

With reference now to FIGS. **3**A and **3**B, additional aspects of the operation of the example compression connector **200** are disclosed. In particular, FIG. **3**A discloses the example compression connector **200** in an initial open position, while FIG. **3**B discloses the example compression connector **200** after having been moved into an engaged position.

As disclosed in FIG. **3**A, the terminal end of the corrugated coaxial cable **100** of FIG. **1**D can be inserted into the example compression connector **200** through the compression sleeve **330**. Once inserted, the increased-diameter cylindrical section **116** of the outer conductor **106** is received into the cylindrical gap **304** defined between the cylindrical outside surface **292** of the mandrel **290** and the cylindrical inside surface **302** of the clamp **300**. Also, once inserted, the jacket seal **320** surrounds the jacket **108** of the corrugated coaxial cable **100**, and the inner conductor **102** is received into the collet portion **274** of the conductive pin **270** such that the conductive pin **270** is mechanically and electrically contacting the inner conductor **102**. As disclosed in FIG. **3**A, the diameter **298** of the cylindrical outside surface **292** of the mandrel **290** is greater than the smallest diameter **122** of the corrugated outer conductor **106**, which is the inside diameter of the valleys **106***a* of the outer conductor **106**.

FIG. **3**B discloses the example compression connector **200** after having been moved into an engaged position. As disclosed in FIGS. **3**A and **3**B, the example compression connector **200** is moved into the engaged position by sliding the compression sleeve **330** along the connector body **230** toward the connector nut **210**. As the compression connector **200** is moved into the engaged position, the inside of the compression sleeve **330** slides over the outside of the connector body **230** until a shoulder **332** of the compression sleeve **330** abuts a shoulder **234** of the connector body **230**. In addition, a distal end **334** of the compression sleeve **330** compresses the third o-ring seal **250** into an annular groove **236** defined in the connector body **230**, thus sealing the compression sleeve **330** to the connector body **230**.

Further, as the compression connector **200** is moved into the engaged position, a shoulder **336** of the compression sleeve **330** axially biases against the jacket seal **320**, which axially biases against the clamp ring **310**, which axially forces the inwardly-tapering outside transition surface **308** of the clamp **300** against an outwardly-tapering inside surface **238** of the connector body **230**. As the surfaces **308** and **238** slide past one another, the clamp **300** is radially forced into the smaller diameter connector body **230**, which radially compresses the clamp **300** and thus reduces the outer diameter of the clamp **300** by narrowing or closing the slot **304** (see FIG. **2**B). As the clamp **300** is radially compressed by the axial force exerted on the compression sleeve **330**, the cylindrical inside surface **302** of the clamp **300** is clamped around the increased-diameter cylindrical section **116** of the outer conductor **106** so as to radially compress the increased-diameter cylindrical section **116** between the cylindrical inside surface **302** of the clamp **300** and the cylindrical outside surface **292** of the mandrel **290**.

In addition, as the compression connector **200** is moved into the engaged position, the clamp **300** axially biases against the annular flange **296** of the mandrel **290**, which axially biases against the conductive pin **270**, which axially forces the conductive pin **270** into the insulator **260** until a shoulder **276** of the collet portion **274** abuts a shoulder **262** of the insulator **260**. As the collet portion **274** is axially forced into the insulator **260**, the fingers **278** of the collet portion **274** are radially contracted around the inner conductor **102** by narrowing or closing the slots **279** (see FIG. **2**B). This radial contraction of the conductive pin **270** results in an increased contact force between the conductive pin **270** and the inner conductor **102**, and can also result in some deformation of the inner conductor **102**, the insulator **260**, and/or the fingers **278**. As used herein, the term "contact force" is the combination of the net friction and the net normal force between the surfaces of two components. This contracting configuration increases the reliability of the mechanical and electrical contact between the conductive pin **270** and the inner conductor **102**. Further, the pin portion **272** of the conductive pin **270** extends past the insulator **260** in order to engage a corresponding conductor of a female connector that is engaged with the connector nut **210** (not shown).

With reference now to FIGS. **3**C and **3**D, aspects of another example compression connector **200"** are disclosed. In particular, FIG. **3**C discloses the example compression connector **200"** in an initial open position, while FIG. **3**D discloses the example compression connector **200"** after having been moved into an engaged position. The example compression connector **200"** is identical to the example compression connector **200** in FIGS. **1**A and **2**A-**3**B, except that the example compression connector **200"** has a modified insulator **260"** and a modified conductive pin **270"**. As disclosed in FIGS. **3**C and **3**D, during the preparation of the terminal end of the coaxial cable **100**, the diameter of the portion of the inner conductor **102** that is configured to be received into the collet portion **274"** can be reduced. This additional diameter-reduction in the inner conductor **102** enables the collet portion **274"** to be modified to have the same or similar outside diameter as the pin portion **272** (excluding the taper at the tip of the pin portion **272**), instead of the enlarged diameter of the collet portion **274** disclosed in FIGS. **3**A and **3**B. Once the compression connector **200"** has been moved into the engaged position, as disclosed in FIG. **3**D, the outside diameter of the collet portion **274"** is substantially equal to the outside diameter of the inner conductor. This additional diameter-reduction in the inner conductor **102** thus enables the outside diameter of the inner conductor **102**, through which the RF signal travels, to remain substantially constant at the transition between the inner conductor **102** and the conductive pin **270"**. Since impedance is a function of the diameter of the inner conductor, as discussed in greater detail below, this additional diameter-reduction in the inner conductor **102** can further improve impedance matching between the coaxial cable **100** and the compression connector **200"**.

With continued reference to FIGS. **3**A and **3**B, as the compression connector **200** is moved into the engaged position, the distal end **239** of the connector body **230** axially biases against the clamp ring **310**, which axially biases against the jacket seal **320** until a shoulder **312** of the clamp ring **310** abuts a shoulder **338** of the compression sleeve **330**. The axial force of the shoulder **336** of the compression sleeve **330** combined with the opposite axial force of the clamp ring **310** axially compresses the jacket seal **320** causing the jacket seal **320** to become shorter in length and thicker in width. The thickened width of the jacket seal **320** causes the jacket seal **320** to press tightly against the jacket **108** of the corrugated coaxial cable **100**, thus sealing the compression sleeve **330** to the jacket **108** of the corrugated coaxial cable **100**. Once sealed, in at least some example embodiments, the narrowest inside diameter **322** of the jacket seal **320**, which is equal to the outside diameter **124** of the valleys of jacket **108**, is less than the sum of the diameter **298** of the cylindrical outside surface **292** of the mandrel **290** plus two times the average thickness of the jacket **108**.

With reference to FIG. **2**B, the mandrel **290** and the clamp **300** are both formed from metal, which makes the mandrel **290** and the clamp **300** relatively sturdy. As disclosed in FIGS. **3**A and **3**B, with both the mandrel **290** and the clamp **300** formed from metal, two separate electrically conductive paths exist between the outer conductor **106** and the connector body **230**. Although these two paths merge where the clamp **300** makes contact with the annular flange **296** of the mandrel **290**, as disclosed in FIG. **3**B, it is understood that these paths may alternatively be separated by creating a substantial gap between the clamp **300** and the annular flange **296**. This substantial gap may further be filled or partially filled with an insulating material, such as a plastic washer for example, to better ensure electrical isolation between the clamp **300** and the annular flange **296**.

Also disclosed in FIGS. **3**A and **3**B, the thickness of the metal inserted portion of the mandrel **290** is about equal to the difference between the inside diameter of the peaks **106***b* (FIG. **1**D) of the corrugated outer conductor **106** and the inside diameter of the valleys **106***a* (FIG. **1**D) of the corrugated outer conductor **106**. It is understood, however, that the thickness of the metal inserted portion of the mandrel **290** could be greater than or less than the thickness disclosed in FIGS. **3**A and **3**B.

It is understood that one of the mandrel **290** or the clamp **300** can alternatively be formed from a non-metal material such as polyetherimide (PEI) or polycarbonate, or from a metal/non-metal composite material such as a selectively metal-plated PEI or polycarbonate material. A selectively metal-plated mandrel **290** or clamp **300** may be metal-plated at contact surfaces where the mandrel **290** or the clamp **300** makes contact with another component of the compression connector **200**. Further, bridge plating, such as one or more metal traces, can be included between these metal-plated contact surfaces in order to ensure electrical continuity between the contact surfaces. It is understood that only one of these two components needs to be formed from metal or from a metal/non-metal composite material in order to create a single electrically conductive path between the outer conductor **106** and the connector body **230**.

The increased-diameter cylindrical section **116** of the outer conductor **106** enables the inserted portion of the mandrel **290** to be relatively thick and to be formed from a material with a relatively high dielectric constant and still maintain favorable impedance characteristics. Also disclosed in FIGS. **3**A and **3**B, the metal inserted portion of the mandrel **290** has an inside diameter that is about equal to the inside diameter **122** of the valleys **106***a* of the corrugated outer conductor **106**. It is understood, however, that the inside diameter of the metal inserted portion of the mandrel **290** could be greater than or less than the inside diameter disclosed in FIGS. **3**A and **3**B. For example, the metal inserted portion of the mandrel **290** can have an inside diameter that is about equal to an average diameter of the valleys **106***a* and the peaks **106***b* (FIG. **1**D) of the corrugated outer conductor **106**.

Once inserted, the mandrel **290** replaces the material from which the insulating layer **104** is formed in the cored-out section **114**. This replacement changes the dielectric constant of the material positioned between the inner conductor **102** and the outer conductor **106** in the cored-out section **114**. Since the impedance of the coaxial cable **100** is a function of the diameters of the inner and outer conductors **102** and **106** and the dielectric constant of the insulating layer **104**, in isolation this change in the dielectric constant would alter the impedance of the cored-out section **114** of the coaxial cable **100**. Where the mandrel **290** is formed from a material that has a significantly different dielectric constant from the dielectric constant of the insulating layer **104**, this change in the dielectric constant would, in isolation, significantly alter the impedance of the cored-out section **114** of the coaxial cable **100**.

However, the increase of the diameter of the outer conductor **106** of the increased-diameter cylindrical section **116** is configured to compensate for the difference in the dielectric constant between the removed insulating layer **104** and the inserted portion of the mandrel **290** in the cored-out section **114**. Accordingly, the increase of the diameter of the outer conductor **106** in the increased-diameter cylindrical section **116** enables the impedance of the cored-out section **114** to remain about equal to the impedance of the remainder of the coaxial cable **100**, thus reducing internal reflections and resulting signal loss associated with inconsistent impedance.

In general, the impedance z of the coaxial cable **100** can be determined using Equation (1):

$$z = \left(\frac{138}{\sqrt{\varepsilon}}\right) * \log\left(\frac{\phi_{OUTER}}{\phi_{INNER}}\right) \tag{1}$$

where ∈ is the dielectric constant of the material between the inner and outer conductors **102** and **106**, $\o_{OUTER}$ is the effective inside diameter of the corrugated outer conductor **106**, and $\o_{DINNER}$ is the outside diameter of the inner conductor **102**. However, once the insulating layer **104** is removed from the cored-out section **114** of the coaxial cable **100** and the metal mandrel **290** is inserted into the cored-out section **114**, the metal mandrel **290** effectively becomes an extension of the metal outer conductor **106** in the cored-out section **114** of the coaxial cable **100**.

In general, the impedance z of the example coaxial cable **100** should be maintained at 50 Ohms. Before termination, the impedance z of the coaxial cable is formed at 50 Ohms by forming the example coaxial cable **100** with the following characteristics:

ϵ=1.100;

$\o_{OUTER}$=0.458 inches;

$\o_{INNER}$=0.191 inches; and

z=50 Ohms.

During termination, however, the inside diameter of the cored-out section **114** of the outer conductor **106** $\o_{OUTER}$ of 0.458 inches is effectively replaced by the inside diameter of the mandrel **290** of 0.440 inches in order to maintain the impedance z of the cored-out section **114** of the coaxial cable **100** at 50 Ohms, with the following characteristics:

ϵ=1.000;

$\o_{OUTER}$ (the inside diameter of the mandrel **290**)=0.440 inches;

$\o_{INNER}$=0.191 inches; and

z=50 Ohms.

Thus, the increase of the diameter of the outer conductor **106** enables the mandrel **290** to be formed from metal and effectively replace the inside diameter of the cored-out section **114** of the outer conductor **106** $\o_{OUTER}$. Further, the increase of the diameter of the outer conductor **106** also enables the mandrel **290** to alternatively be formed from a non-metal material having a dielectric constant that does not closely match the dielectric constant of the material from which the insulating layer **104** is formed.

As disclosed in FIGS. **3**A and **3**B, the particular increased diameter of the increased-diameter cylindrical section **116** correlates to the shape and type of material from which the mandrel **290** is formed. It is understood that any change to the shape and/or material of the mandrel **290** may require a corresponding change to the diameter of the increased-diameter cylindrical section **116**.

As disclosed in FIGS. **3**A and **3**B, the increased diameter of the increased-diameter cylindrical section **116** also facilitates an increase in the thickness of the mandrel **290**. In addition, as discussed above, the increased diameter of the increased-diameter cylindrical section **116** also enables the mandrel **290** to be formed from a relatively sturdy material such as metal. The relatively sturdy mandrel **290**, in combination with the cylindrical configuration of the increased diameter cylindrical section **116**, enables a relative increase in the amount of radial force that can be directed inward on the increased-diameter cylindrical section **116** without collapsing the increased-diameter cylindrical section **116** or the mandrel **290**. Further, the cylindrical configuration of the increased-diameter cylindrical section **116** enables the inwardly-directed force to have primarily a radial component and have substantially no axial component, thus removing any dependency on a continuing axial force which can tend to decrease over time under extreme weather and temperature conditions. It is understood, however, that in addition to the primarily radial component directed to the increased-diameter cylindrical section **116**, the example compression connector **200** may additionally include one or more structures that exert an inwardly-directed force having an axial component on another section or sections of the outer conductor **106**.

This relative increase in the amount of force that can be directed inward on the increased-diameter cylindrical section **116** increases the security of the mechanical and electrical contacts between the mandrel **290**, the increased-diameter cylindrical section **116**, and the clamp **300**. Further, the contracting configuration of the insulator **260** and the conductive pin **270** increases the security of the mechanical and electrical contacts between the conductive pin **270** and the inner conductor **102**. Even in applications where these mechanical and electrical contacts between the compression connector **200** and the coaxial cable **100** are subject to stress due to high wind, precipitation, extreme temperature fluctuations, and vibration, the relative increase in the amount of force that can be directed inward on the increased diameter cylindrical section **116**, combined with the contracting configuration of the insulator **260** and the conductive pin **270**, tend to maintain these mechanical and electrical contacts with relatively small degradation over time. These mechanical and electrical contacts thus reduce, for example, micro arcing or corona discharge between surfaces, which reduces the PIM levels and associated creation of interfering RF signals that emanate from the example compression connector **200**.

FIG. **4**A discloses a chart **350** showing the results of PIM testing performed on a coaxial cable that was terminated using a prior art compression connector. The PIM testing that produced the results in the chart **350** was performed under dynamic conditions with impulses and vibrations applied to the prior art compression connector during the testing. As disclosed in the chart **350**, the PIM levels of the prior art compression connector were measured on signals F**1** and F**2** to significantly vary across frequencies 1870-1910 MHz. In addition, the PIM levels of the prior art compression connector frequently exceeded a minimum acceptable industry standard of −155 dBc.

In contrast, FIG. **4**B discloses a chart **375** showing the results of PIM testing performed on the coaxial cable **100** that was terminated using the example compression connector **200**. The PIM testing that produced the results in the chart **375** was also performed under dynamic conditions with impulses and vibrations applied to the example compression connector **200** during the testing. As disclosed in the chart **375**, the PIM levels of the example compression **200** were measured on signals F**1** and F**2** to vary significantly less across frequencies 1870-1910 MHz. Further, the PIM levels of the example compression connector **200** remained well below the minimum acceptable industry standard of −155 dBc. These superior PIM levels of the example compression connector **200** are due at least in part to the cylindrical configurations of the increased-diameter cylindrical section **116**, the cylindrical outside surface **292** of the mandrel **290**, and the cylindrical inside surface **302** of the clamp **300**, as well as the contracting configuration of the insulator **260** and the conductive pin **270**.

It is noted that although the PIM levels achieved using the prior art compression connector generally satisfy the minimum acceptable industry standard of −140 dBc (except at 1906 MHz for the signal F**2**) required in the 2G and 3G wireless industries for cellular communication towers. However, the PIM levels achieved using the prior art compression connector fall below the minimum acceptable industry standard of −155 dBc that is currently required in the 4G wireless industry for cellular communication towers. Compression connectors having PIM levels above this minimum acceptable standard of −155 dBc result in interfering RF signals that disrupt communication between sensitive receiver and transmitter equipment on the tower and lower-powered cellular devices in 4G systems. Advantageously, the relatively low PIM levels achieved using the example compression connector **200** surpass the minimum acceptable level of −155 dBc, thus reducing these interfering RF signals. Accordingly, the example field-installable compression connector **200** enables coaxial cable technicians to perform terminations of coaxial cable in the field that have sufficiently low levels of PIM to enable reliable 4G wireless communication. Advantageously, the example field installable compression connector **200** exhibits impedance matching and PIM characteristics that match or exceed the corresponding characteristics of less convenient factory-installed soldered or welded connectors on pre-fabricated jumper cables.

In addition, it is noted that a single design of the example compression connector **200** can be field-installed on various manufacturers' coaxial cables despite slight differences in the cable dimensions between manufacturers. For example, even though each manufacturer's ½" series corrugated coaxial cable has a slightly different sinusoidal period length, valley diameter, and peak diameter in the corrugated outer conductor, the preparation of these disparate corrugated outer conductors to have a substantially identical increased-diameter cylindrical section **116**, as disclosed herein, enables each of these disparate cables to be terminated using a single compression connector **200**. Therefore, the design of the example compression connector **200** avoids the hassle of having to employ a different connector design for each different manufacturer's corrugated coaxial cable.

Further, the design of the various components of the example compression connector **200** is simplified over prior art compression connectors. This simplified design enables these components to be manufactured and assembled into the example compression connector **200** more quickly and less expensively.

IV. Another Example Coaxial Cable and Example Compression Connector

With reference now to FIG. **5**A, a second example coaxial cable **400** is disclosed. The example coaxial cable **400** also has 50 Ohms of impedance and is a ½" series smooth-walled coaxial cable. It is understood, however, that these cable characteristics are example characteristics only, and that the example compression connectors disclosed herein can also benefit coaxial cables with other impedance, dimension, and shape characteristics.

Also disclosed in FIG. **5**A, the example coaxial cable **400** is also terminated on the right side of FIG. **5**A with an example compression connector **200'** that is identical to the example compression connector **200** in FIGS. **1**A and **2**A-**3**B, except that the example compression connector **200'** has a different jacket seal, as shown and discussed below in connection with FIGS. **6**A and **6**B. It is understood, however, that the example coaxial cable **400** could be configured to be terminated with the example compression connector **200** instead of the example compression connector **200'**. For example, where the outside diameter of the example coaxial cable **400** is the same or similar to the maximum outside diameter of the example coaxial cable **100**, the jacket seal of the example compression connector **200** can function to seal both types of cable. Therefore, a single compression connector can be used to terminate both types of cable.

With reference now to FIG. **5**B, the coaxial cable **400** generally comprises an inner conductor **402** surrounded by an insulating layer **404**, a smooth-walled outer conductor **406** surrounding the insulating layer **404**, and a jacket **408** surrounding the smooth-walled outer conductor **406**. The inner conductor **402** and insulating layer **404** are identical in form and function to the inner conductor **102** and insulating layer **104**, respectively, of the example coaxial cable **100**. Further, the smooth-walled outer conductor **406** and jacket **408** are identical in form and function to the corrugated outer conductor **106** and jacket **108**, respectively, of the example coaxial cable **400**, except that the outer conductor **406** and jacket **408** are smooth walled instead of corrugated. The smooth-walled configuration of the outer conductor **406** enables the coaxial cable **400** to be generally more rigid than cables with corrugated outer conductors.

As disclosed in FIG. **5**C, an alternative coaxial cable **400'** comprises an alternative insulating layer **404'** composed of a spiral-shaped spacer that is identical in form and function to the alternative insulating layer **104'** of FIG. **1**C. Accordingly, the example compression connector **200'** disclosed herein can similarly benefit the alternative coaxial cable **400'**.

With reference to FIG. **5**D, a terminal end of the coaxial cable **400** is disclosed after having been prepared for termination with the example compression connector **200'**, disclosed in FIGS. **5**A and **6**A-**6**B. As disclosed in FIG. **5**D, the terminal end of the coaxial cable **400** comprises a first section **410**, a second section **412**, a cored-out section **414**, and an increased-diameter cylindrical section **416**. The jacket **408**, smooth-walled outer conductor **406**, and insulating layer **404** have been stripped away from the first section **410**. The jacket **408** has been stripped away from the second section **412**. The insulating layer **404** has been cored out from the cored out section **414**. The diameter of a portion of the smooth-walled outer conductor **406** that surrounds the cored-out section **414** has been increased so as to create the increased-diameter cylindrical section **416** of the outer conductor **406**. This increasing of the diameter of the smooth-walled outer conductor **406** can be accomplished as discussed above in connection with the increasing of the diameter of the corrugated outer conductor **106** in FIG. **1**D.

As disclosed in FIG. **5**D, the increased-diameter cylindrical section **416** of the smooth-walled outer conductor **406** has a substantially uniform diameter throughout the length of the section **416**. The length of the increased-diameter cylindrical section **416** should be sufficient to allow a force to be directed inward on the increased-diameter cylindrical section **416**, once the smooth-walled coaxial cable **400** is terminated with the example compression connector **200'**, with the inwardly directed force having primarily a radial component and having substantially no axial component.

As disclosed in FIG. **5**D, the length of the increased-diameter cylindrical section **416** is thirty-three times the thickness **418** of the outer conductor **406**. It is understood, however, that the length of the increased-diameter cylindrical section **416** could be any length from two times the thickness **418** of the outer conductor **406** upward. It is further understood that the tools and/or processes that fashion the increased-diameter cylindrical section **416** may further create increased diameter portions of the smooth-walled outer conductor **406** that are not cylindrical. The preparation of the terminal section of the example smooth-walled coaxial cable **400** disclosed in FIG. **5**D can be accomplished as discussed above in connection with the example corrugated coaxial cable **100**.

V. Cable Termination Using the Example Compression Connector

With reference now to FIGS. **6**A and **6**B, aspects of the operation of the example compression connector **200'** are disclosed. In particular, FIG. **6**A discloses the example compression connector **200'** in an initial open position, while FIG. **6**B discloses the example compression connector **200'** after having been moved into an engaged position.

As disclosed in FIG. **6**A, the terminal end of the smooth-walled coaxial cable **400** of FIG. **5**D can be inserted into the example compression connector **200'** through the compression sleeve **330**. Once inserted, the increased-diameter cylindrical section **416** of the outer conductor **406** is received into the cylindrical gap **304** defined between the cylindrical outside surface **292** of the mandrel **290** and the cylindrical inside surface **302** of the clamp **300**. Also, once inserted, the jacket seal **320'** surrounds the jacket **408** of the smooth-walled coaxial cable **400**, and the inner conductor **402** is received into the collet portion **274** of the conductive pin **270** such that the conductive pin **270** is mechanically and electrically contacting the inner conductor **402**. As disclosed in FIG. **6**A, the diameter **298** of the cylindrical outside surface **292** of the mandrel **290** is greater than the smallest diameter **420** of the smooth-walled outer conductor **406**, which is the inside diameter of the outer conductor **406**. Further, the jacket seal **320'** has an inside diameter **322'** that is less than the sum of the diameter **298** of the cylindrical outside surface **292** of the mandrel **290** plus two times the thickness of the jacket **408**.

FIG. **6**B discloses the example compression connector **200'** after having been moved into an engaged position. The example compression connector **200'** is moved into an engaged position in an identical fashion as discussed above in connection with the example compression connector **200** in FIGS. **3**A and **3**B. As the compression connector **200'** is moved into the engaged position, the clamp **300** is radially compressed by the axial force exerted on the compression sleeve **330** and the cylindrical inside surface **302** of the clamp **300** is clamped around the increased diameter cylindrical section **416** of the outer conductor **406** so as to radially compress the increased-diameter cylindrical section **416** between the cylindrical inside surface **302** of the clamp **300** and the cylindrical outside surface **292** of the mandrel **290**.

In addition, as the compression connector **200'** is moved into the engaged position, the axial force of the shoulder **336** of the compression sleeve **330** combined with the opposite axial force of the clamp ring **310** axially compresses the jacket seal **320'** causing the jacket seal **320'** to become shorter in length and thicker in width. The thickened width of the jacket seal **320'** causes the jacket seal **320'** to press tightly against the jacket **408** of the smooth-walled coaxial cable **400**, thus sealing the compression sleeve **330** to the jacket **408** of the smooth-walled coaxial cable **400**. Once sealed, the narrowest inside diameter **322'** of the jacket seal **320'**, which is equal to the outside diameter **124'** of the jacket **408**, is less than the sum of the diameter **298** of the cylindrical outside surface **292** of the mandrel **290** plus two times the thickness of the jacket **408**.

As noted above in connection with the example compression connector **200**, the termination of the smooth-walled coaxial cable **400** using the example compression connector **200'** enables the impedance of the cored-out section **414** to remain about equal to the impedance of the remainder of the coaxial cable **400**, thus reducing internal reflections and resulting signal loss associated with inconsistent impedance. Further, the termination of the smooth-walled coaxial cable **400** using the example compression connector **200'** enables improved mechanical and electrical contacts between the mandrel **290**, the increased-diameter cylindrical section **416**, and the clamp **290**, as well as between the inner conductor **402** and the conductive pin **270**, which reduces the PIM levels and associated creation of interfering RF signals that emanate from the example compression connector **200'**.

VI. Another Example Compression Connector

With reference now to FIGS. **7**A and **7**B, another example compression connector **500** is disclosed. The example compression connector **500** is configured to terminate either smooth-walled or corrugated 50 Ohm ⅞" series coaxial cable. Further, although the example compression connector **500** is disclosed in FIG. **7**A as a female compression connector, it is understood that the compression connector **500** can instead be configured as a male compression connector (not shown).

As disclosed in FIGS. **7**A and **7**B, the example compression connector **500** comprises a connector body **510**, a first o-ring seal **520**, a second o-ring seal **525**, a first insulator **530**, a conductive pin **540**, a guide **550**, a second insulator **560**, a mandrel **590**, a clamp **600**, a clamp ring **610**, a jacket seal **620**, and a compression sleeve **630**. The connector body **510**, first o-ring seal **520**, second o-ring seal **525** mandrel **590**, clamp **600**, clamp ring **610**, jacket seal **620**, and compression sleeve **630** function similarly to the connector body **230**, second o-ring seal, third o-ring seal **250**, mandrel **290**, clamp **300**, clamp ring **310**, jacket seal **320**, and compression sleeve **330**, respectively. The first insulator **530**, conductive pin **540**, guide **550**, and second insulator **560** function similarly to the insulator 13, pin 14, guide 15, and insulator 16 disclosed in U.S. Pat. No. 7,527,512, titled "CABLE CONNECTOR EXPANDING CONTACT," which issued May 5, 2009 and is incorporated herein by reference in its entirety.

As disclosed in FIG. **7**B, the conductive pin **540** comprises a plurality of fingers **542** separated by a plurality of slots **544**. The guide **550** comprises a plurality of corresponding tabs **552** that correspond to the plurality of slots **544**. Each finger **542** comprises a ramped portion **546** (see FIG. **7**C) on an underside of the finger **542** which is configured to interact with a ramped portion **554** of the guide **550**. The second insulator **560** is press fit into a groove **592** formed in the mandrel **590**.

With reference to FIGS. **7**C and **7**D, additional aspects of the example compression connector **500** are disclosed. FIG. **7**C discloses the example compression connector in an open position. FIG. **7**D discloses the example compression connector **500** in an engaged position.

As disclosed in FIG. **7**C, a terminal end of an example corrugated coaxial cable **700** can be inserted into the example compression connector **500** through the compression sleeve **630**. It is noted that the example compression connector **500** can also be employed in connection with a smooth-walled coaxial cable (not shown). Once inserted, portions of the guide **550** and the conductive pin **540** can slide easily into the hollow inner conductor **702** of the coaxial cable **700**.

As disclosed in FIGS. **7**C and **7**D, as the compression connector **500** is moved into the engaged position, the conductive pin **540** is forced into the inner conductor **702** beyond the ramped portions **554** of the guide **550** due to the interaction of the tabs **552** and the second insulator **560**, which causes the conductive pin **540** to slide with respect to the guide **550**. This sliding action forces the fingers **542** to radially expand due to the ramped portions **546** interacting with the ramped portion **554**. This radial expansion of the conductive pin **540** results in an increased contact force between the conductive pin **540** and the inner conductor **702**, and can also result in some deformation of the inner conductor **702**, the guide **550**, and/or the fingers **542**. This expanding configuration increases the reliability of the mechanical and electrical contact between the conductive pin **540** and the inner conductor **702**.

As noted above in connection with the example compression connectors **200** and **200'**, the termination of the corrugated coaxial cable **700** using the example compression connector **500** enables the impedance of the cored-out section **714** of the cable **700** to remain about equal to the impedance of the remainder of the cable **700**, thus reducing internal reflections and resulting signal loss associated with inconsistent impedance. Further, the termination of the corrugated coaxial cable **700** using the example compression connector **500** enables improved mechanical and electrical contacts between the mandrel **590**, the increased-diameter cylindrical section **716**, and the clamp **600**, as well as between the inner conductor **702** and the conductive pin **540**, which reduces the PIM levels and associated creation of interfering RF signals that emanate from the example compression connector **500**.

The example embodiments disclosed herein may be embodied in other specific forms. The example embodiments disclosed herein are to be considered in all respects only as illustrative and not restrictive.

What is claimed is:

1. A coaxial cable connector comprising:
   - a coupler comprising a first coupler end and a second coupler end;
   - a component configured to extend along an axis and at least partially receive an inner conductor of a cable end of a coaxial cable, having an insulator surrounding the inner conductor, and a corrugated outer conductor surrounding the insulator, the corrugated outer conductor including an end section having an outer surface region and an inner surface region located opposite of the outer surface region, the inner surface region defining a first space, the component comprising a support surface configured to be at least an inner conductor engager defining a second space configured to at least partially receive the inner conductor, the inner conductor engager comprising a plurality of fingers surrounding the second space;
   - an outer conductor engager including a first portion extending along a first direction parallel to the axis and a second portion extending along a second direction that is not parallel to the axis, the first portion being configured to at least partially receive the end section as the end section is non-rotatably slid along the axis relative to the outer conductor engager; and
   - a compressor configured to at least partially receive the component, the compressor having a first compressor end and a second compressor end, the first compressor end configured to be located closer to the coupler than the second compressor end,
   - wherein the coupler and the compressor are configured to be arranged so that there is a first distance between the first coupler end and the second compressor end,
   - wherein the coaxial cable connector is configured to enable the compressor to axially move along the axis relative to the coupler as a result of at least one axial installation force acting along the axis, and
   - wherein the coaxial cable connector is configured so that:
     - the second space at least partially receives the inner conductor resulting from the axial movement;
     - the fingers engage the inner conductor resulting from the axial movement;
     - at least part of the end section is compressed between the outer conductor engager and the support surface resulting from the axial movement,
   - wherein the support surface abuts the inner surface region when at least one of the portions of the outer conductor engager abuts the outer surface region;
     - the compression applies a force to the outer conductor resulting from the axial movement, wherein at least part of the force acts in a radial direction, and
     - also resulting from the axial movement, the coupler and the compressor move closer together along the axis so that there is a second distance between the first coupler end and the second compressor end, wherein the second distance is less than the first distance.

2. The coaxial cable connector of claim **1**, wherein the coupler comprises a threaded nut.

3. The coaxial cable connector of claim **1**, wherein the fingers are configured to flex.

4. The coaxial cable connector of claim **1**, wherein the component comprises a mandrel.

5. The coaxial cable connector of claim **1**, wherein the compressor has a substantially tubular shape.

6. The coaxial cable connector of claim **1**, wherein the compressor comprises a compression sleeve.

7. The coaxial cable connector of claim **1**, wherein the component comprises a tubular shape.

8. The coaxial cable connector of claim **1**, wherein the coaxial cable connector comprises a body configured to be rotatably coupled to the second coupler end, the body being extendable along the axis, the body configured to at least partially receive the inner conductor, the body also configured to at least partially receive the component.

9. The coaxial cable connector of claim **1**, wherein the support surface comprises an inwardly tapered outside surface.

10. The coaxial cable connector of claim **1**, wherein at least one of the support surface and one of the portions of the outer conductor engager extends in a first plane that is parallel with a second plane through which the end section extends.

11. The coaxial cable connector of claim **1**, wherein the corrugated outer conductor comprises a plurality of peaks and a plurality of valleys, the compressed part extending at least partially from one of the peaks or valleys, the compressed part extending to a terminal edge of the end section.

12. The coaxial cable connector of claim **1**, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the compressed part is clamped between the support surface and one of the portions of the outer conductor engager so as to eliminate a conduction disruption gap between the support surface and the inner surface region of the corrugated outer conductor.

13. The coaxial cable connector of claim **1**, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the support surface abuts the inner surface region when the first portion of the outer conductor engager abuts the outer surface region.

14. The coaxial cable connector of claim **1**, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the corrugated outer conductor is prevented from being disengaged from the outer conductor engager without application of a disengagement force that is selected from the group consisting of: (a) a disengagement force that, when applied to the coaxial cable connector, would exceed a strength limit of the coaxial cable; and (b) a disengagement force that, when applied to the coaxial cable connector, would cause the coaxial cable connector to become unassembled from an assembled, compressed state, and wherein a process other than a screwing process would be required to return the coaxial cable connector to the assembled, compressed state.

15. The coaxial cable connector of claim **1**, wherein the corrugated outer conductor has a corrugation selected from the group consisting of an annular corrugation and a helical corrugation.

16. The coaxial cable connector of claim **1**, wherein the outer conductor engager comprises a clamp.

17. The coaxial cable connector of claim **16**, wherein the corrugated outer conductor comprises a maximum diameter, and the first portion of the outer conductor engager has a minimum diameter that is no less than the maximum diameter.

18. The coaxial cable connector of claim **1**, wherein the coaxial cable comprises a jacket surrounding the corrugated outer conductor, the coaxial cable connector comprises a jacket seal configured to engage the jacket, and wherein as a result of the axial movement, the jacket seal is engaged with the jacket.

19. The coaxial cable connector of claim **18**, wherein the coaxial cable connector comprises a compression member configured to compress the jacket seal.

20. The coaxial cable connector of claim **18**, wherein a portion of the coaxial cable connector is configured to receive the jacket and to define, as a result of the axial movement, a third space between the jacket and the portion, and wherein the jacket seal is at least partially positioned within the third space.

21. A coaxial cable connector comprising:

a coupler;

a component extendable along an axis, the component configured to receive an inner conductor of an end of a coaxial cable, the coaxial cable comprising a corrugated outer conductor surrounding the inner conductor, the corrugated outer conductor comprising an end section, the end section defining a first space, the component comprising a support surface configured to be at least partially inserted into the first space;

an inner conductor engager defining a second space configured to at least partially receive the inner conductor;

an outer conductor engager configured to at least partially surround the corrugated outer conductor, the outer conductor engager comprising a plurality of portions, at least one of the portions extending parallel to the axis, the at least one portion configured to at least partially receive the end section when the end section non-rotatably slides along the axis relative to the outer conductor engager; and

a compressor configured to be coupled to the component;

wherein the coaxial cable connector is configured to have a first length when the coaxial cable connector is in an uninstalled state,

wherein the coaxial cable connector is configured to enable the compressor to axially move along the axis relative to the coupler as a result of at least one axial installation force acting along the axis, and

wherein the coaxial cable connector is configured so that:

the second space at least partially receives the inner conductor resulting from the axial movement;

at least part of the end section is clamped between the support surface and one of the portions of the outer conductor engager resulting from the axial movement;

the clamping of the at least part of the end section applies an engagement force to the at least part resulting from the axial movement, wherein the engagement force acts at least partially in a radial direction; and

also resulting from the axial movement, the coaxial cable connector has a second length when the coaxial cable connector is in an installed state, wherein the second length is less than the first length.

22. The coaxial cable connector of claim **21**, wherein the coupler comprises a threaded nut.

23. The coaxial cable connector of claim **21**, wherein the inner conductor engager comprises a plurality of flexible fingers.

24. The coaxial cable connector of claim **21**, wherein the outer conductor engager comprises a clamp.

25. The coaxial cable connector of claim **21**, wherein the component comprises a mandrel.

26. The coaxial cable connector of claim **21**, wherein the coaxial cable connector comprises a body configured to be rotatably coupled to the coupler to extend along the axis, to at least partially receive the inner conductor, and to at least partially receive the component.

27. The coaxial cable connector of claim **21**, wherein the support surface comprises an inwardly tapered outside surface.

28. The coaxial cable connector of claim **21**, wherein at least one of the support surface and one of the portions of the outer conductor engager extends in a first plane that is parallel with a second plane through which the clamped part of the end section extends.

29. The coaxial cable connector of claim **21**, wherein the corrugated outer conductor comprises a plurality of peaks and a plurality of valleys, wherein the clamped part extends at least partially from one of the peaks or valleys and extends to a terminal edge of the end section.

30. The coaxial cable connector of claim **21**, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the clamping eliminates a conduction disruption gap between the support surface and the clamped part of the end section of the outer conductor.

31. The coaxial cable connector of claim **21**, wherein the end section comprises an outer surface region and an inner surface region opposite of the outer surface region, wherein the inner surface region defines the first space, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the support surface abuts the inner surface region when the at least one portion of the outer conductor engager abuts the outer surface region.

32. The coaxial cable connector of claim **21**, wherein the coaxial cable connector is configured so that, as a result of the axial movement, the corrugated outer conductor is prevented from being disengaged from the outer conductor engager without application of a disengagement force that is selected from the group consisting of: (a) a disengagement force that, when applied to the coaxial cable connector, would exceed a strength limit of the coaxial cable; and (b) a disengagement force that, when applied to the coaxial cable connector, would cause the coaxial cable connector to become unassembled from an assembled, compressed state, and wherein a process other than a screwing process would be required to return the coaxial cable connector to the assembled, compressed state.

33. The coaxial cable connector of claim **21**, wherein the corrugated outer conductor has a corrugation selected from the group consisting of an annular corrugation and a helical corrugation.

34. The coaxial cable connector of claim **21**, wherein the coaxial cable comprises a jacket surrounding the outer conductor, wherein the coaxial cable connector comprises a jacket seal configured to engage the jacket, and wherein as a result of the axial movement, the jacket seal is engaged with the jacket.

35. The coaxial cable connector of claim **34**, wherein the coaxial cable connector comprises a compression member configured to compress the jacket seal.

36. The coaxial cable connector of claim **34**, wherein a portion of the coaxial cable connector is configured to receive the jacket, wherein, as a result of the axial movement, the portion defines a third space between the jacket and the portion, and wherein the jacket seal is at least partially positioned within the third space.

37. The coaxial cable connector of claim **21**, wherein the corrugated outer conductor has a maximum diameter, and wherein the at least one portion of the outer conductor engager comprises a minimum diameter that is greater than the maximum diameter of the corrugated outer conductor.

38. The coaxial cable connector of claim **37**, wherein the component comprises a mandrel.

39. The coaxial cable connector of claim **21**, wherein the compressor has a substantially tubular shape.

40. The coaxial cable connector of claim **39**, wherein the compressor comprises a compression sleeve.

41. A connector for a coaxial cable having an inner conductor and a corrugated outer conductor surrounding the inner conductor, the corrugated outer conductor including an end section having an outer surface region and an inner surface region located opposite from the outer surface region, and the inner surface region defining a first space, the connector comprising:

a coupler configured to extend along an axis;

a component configured to extend along the axis and to at least partially receive the inner conductor, the component having a tubular shape and a support surface configured to be at least partially inserted into the first space;

an inner conductor engager defining a second space configured to at least partially receive the inner conductor;

an outer conductor engager configured to at least partially receive the corrugated outer conductor and non-rotatably slide along the axis relative to an end section of a corrugated outer conductor of a coaxial cable, the outer conductor engager comprising a plurality of inner surfaces, at least one of the inner surfaces configured to extend parallel to the axis and to at least partially receive the end section when the outer conduct engager non-rotatably slides along the axis relative to the end section of the corrugated outer conductor; and

a sleeve configured to at least partially receive the component;

wherein the connector is configured to allow the sleeve to axially move along the axis from a first position, where the second space receives part of the inner conductor, where the inner conductor engager engages the received part of the inner conductor, and where the outer conductor engager receives at least part of the end section, to a second position, where the outer conductor engager applies a radial force to the received part of the end section, where the received part of the end section is compressed between the outer conductor engager and the support surface, and where the support surface abuts the inner surface region of the received part of the end section when the at least one inner surface of the outer conductor engager abuts the outer surface region of the end section; and

wherein a length of the connector is reduced when the connector moves from the first position to the second position.

42. The connector of claim **41**, wherein the coupler comprises a threaded nut.

43. The connector of claim **41**, wherein the inner conductor engager comprises a plurality of fingers.

44. The connector of claim **41**, wherein the outer conductor engager comprises a clamp.

45. The connector of claim **41**, wherein the corrugated outer conductor comprises a maximum diameter, and the at least one inner surface of the outer conductor engager has a minimum diameter that is no less than the maximum diameter.

46. The connector of claim **41**, wherein the component comprises a mandrel.

47. The connector of claim **41**, wherein the sleeve comprises a compression sleeve.

48. The connector of claim **41**, comprising a body configured to be rotatably coupled to the coupler, to extend along the axis, to at least partially receive the inner conductor, and to at least partially receive the component.

49. The connector of claim **41**, wherein the support surface comprises an inwardly tapered outside surface.

50. The connector of claim **41**, wherein at least one of the support surface and the at least one inner surface of the outer conductor engager extends in a first plane that is parallel with a second plane through which the received part of the end section extends.

51. The connector of claim **41**, wherein the corrugated outer conductor comprises a plurality of peaks and a plurality of valleys, wherein the received part of the end section extends at least partially from one of the peaks or valleys, and wherein the received part of the end section extends to a terminal edge of the end section.

52. The connector of claim **41**, wherein the connector is configured to clamp the received part of the end section between the support surface and the at least one inner surface of the outer conductor engager when the connector moves from the first position to the second position so as to prevent a gap from disrupting conduction between the support surface and the inner surface region of the corrugated outer conductor.

53. The connector of claim **41**, wherein the connector is configured to be non-rotatably moved from a uncompressed state to a compressed state such that the connector cannot be rotatably returned to the uncompressed state.

54. The connector of claim **41**, wherein the connector is configured to be non-rotatably moved from a uncompressed state to a compressed state such that the connector cannot be rotatably returned to the uncompressed state during normal operating conditions of the connector and without applying excessive force to the connector.

55. The connector of claim **41**, wherein the connector is configured to be non-rotatably moved from an assembled, uncompressed state to an assembled, compressed state such that the connector cannot be returned to the assembled, uncompressed state by unscrewing the connector.

56. The connector of claim **41**, wherein the corrugated outer conductor has a corrugation selected from the group consisting of an annular corrugation and a helical corrugation.

57. The connector of claim **41**, wherein the connector is configured to be non-twistably moved from a uncompressed state to a compressed state such that the connector cannot be twistably returned to the uncompressed state during normal operating conditions of the connector and without applying excessive force to the connector.

58. The connector of claim **41**, wherein the connector is configured to be non-twistably moved from an assembled, uncompressed state to an assembled, compressed state such that the connector cannot be returned to the assembled, uncompressed state by untwisting the connector.

59. The connector of claim **41**, wherein the connector is configured to prevent the corrugated outer conductor from being disengaged from the outer conductor engager without applying a disengagement force when the connector moves from the first position to the second position.

60. The connector of claim **59**, wherein the disengagement force comprises a force that would exceed a strength limit of the coaxial cable when applied to the connector.

61. The connector of claim **59**, wherein the disengagement force comprises a force that would cause the connector to become unassembled from an assembled, compressed state when applied to the connector.

62. The connector of claim **41**, wherein the coaxial cable comprises a jacket surrounding the corrugated outer conductor, wherein the connector comprises a jacket seal configured to engage the jacket, and wherein the jacket seal is configured to engage the jacket when the connector moves from the first position to the second position.

63. The connector of claim **62**, wherein the connector comprises a compression member configured to compress the jacket seal.

64. The connector of claim **62**, wherein a portion of the connector is configured to receive the jacket and define a third space between the jacket and the portion when the connector moves from the first position to the second position, and wherein the jacket seal is configured to be at least partially positioned within the third space.

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